NOTES

FOR

STUDENTS IN CHEMISTRY

From the Author.

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BEING A SYLLABUS OF CHEMISTRY

COMPILED MAINLY FROM THE MANUALS OF FOWNES-WATTS, MILLER, WURZ, AND SCHORLEMMER

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PREFACE.

Soon after my appointment to the Chair of Chemistry at St. Mary's Hospital in 1854, I noticed that the chief part of the lecture-time was occupied by the most diligent students in taking notes of the various formulæ and reactions which were from time to time stated; and that they were thereby prevented from paying continuous attention to the course of the Lecture, and its illustrative experiments.

To remedy this evil, I published in 1855 the first edition of my "Notes for Students," in which I endeavoured to supply all the information necessary to form a connecting basis for the teaching in the lectures.

In the present edition, the "Analytical Notes for Students" have been omitted, in order to allow of increased space: these Analytical Notes will be published separately.

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BERNAYS'S NOTES

FOR

STUDENTS IN CHEMISTRY.

MANIFOLD as are the substances which we meet with on every hand, there are but few bodies which cannot be resolved by heat or otherwise into simpler forms. Such as resist all attempts at decomposition are called **Elements** or **simple bodies**.

The quantities of one element which can unite with a constant quantity of another, increase by successive steps, according to simple numerical ratios. Thus, two parts by weight of Hydrogen can unite with sixteen parts by weight of oxygen, and further with thirty-two parts by weight of the same element Oxygen. This fact has led to the idea that the elementary bodies are made up of indivisible particles called **Atoms**, each having a constant weight peculiar to itself. A collection of elementary atoms united together to form a compound, constitutes a **Molecule**, the weight of which is equal to the weight of the sum of its component atoms. Thus an atom of Oxygen weighing 16 unites with 2 atoms of Hydrogen, each atom weighing 1, to form a molecule of hydrogen oxide or Water, weighing $16 + 2 = 18$.

These combinations are represented by symbols, the **initial** letter of the element denoting the atom Thus **Iodine** is represented by I; it unites with **Hydrogen** H, to form a compound, the molecule of which is expressed by the letters **HI.** A group of two or more atoms is expressed by a numeral either before the symbol, or by a small numeral to the right of the symbol. Thus 2I or I_2 denote 2 atoms of Iodine; but I_2O_5 indicates a compound of 2 atoms of iodine with 5 atoms of oxygen.

When one element takes the place of another in combination, the substitution always occurs in proportions which are fixed, definite and invariable. The relative quantities of different elements which thus replace one another, are called **Equivalents** or **Chemical Equivalents:** they are either identical with the atomic weights, or simple multiples or submultiples of them. When Zinc takes the place of Hydrogen, the quantity of Zinc is

only one-half its atomic weight: but, when potassium does so the equivalents are in the same proportion as their **atomic weights.**

Chemical reactions may be represented **symbolically** in the form of **equations**, the symbols of the reagents being placed to the left, and those of the results on the same line to the right, only separated by $\doteq$. Thus: $K_2 + OH_2 = OK_2 + H_2$. In this case, the molecule of KALIUM (potassium) decomposes the molecule of WATER, into the molecule of POTASSOXIDE, and the molecule of HYDROGEN. Multivalent elements often exhibit varying degrees of equivalency. Thus Carbon is **quadrivalent** in CH_4 and **bivalent** in CO. **Nitrogen** is **univalent** in N_2O, **trivalent** in N_2O_3 and **quinquivalent** in N_2O_5. The variation mostly takes place by two units of equivalency.

The **atomic weights** of those elements which are known to exist as gas or vapor, are, as a rule, **proportional to their specific gravities.** Taking the specific gravity of hydrogen as 1, then are the sp. grs. of Oxygen, Nitrogen, Chlorine and Fluorine, and of the vapors of Bromine, Iodine, Sulphur, Selenium and Tellurium (compared under the same conditions of temperature and pressure), **identical with their atomic weights.** Exceptions to this rule are exhibited by arsenicum and phosphorus, whose vapor-densities are twice their atomic weights, and by Cadmium and Mercury, whose vapor-densities equal only half their respective atomic weights. With these exceptions, the **combining volumes of all elementary gases are equal.** The molecules of compound bodies in the gaseous state occupy the space of two volumes of hydrogen. As the molecule of an elementary gas is made up of two atoms, it may be said that **equal volumes of all gases contain equal numbers of molecules,** or, that the molecules of all gases occupy equal volumes (Law of Avogadro). Thus is afforded a sure mode of fixing the molecular constitution of all compounds obtainable as gases, and of ascertaining the atomic weights of the elements.

When it is said that the **sp. gr.** of any **compound gas** or vapor, referred to hydrogen as unity, is **equal to half its atomic** or **molecular weight**, it must be remembered that a few exceptions are known. Thus AMMONIUM CHLORIDE ClH_4N, occupies, as vapor, four times the space of an atom of hydrogen. The same exceptions we have in the cases of PHOSPHORIC CHLORIDE Cl_5P; OIL OF VITRIOL $SO_2(OH)_2$; MERCUROUS CHLORIDE Hg_2Cl_2; AMMONIUM HYDROGEN SULPHIDE **$SH(H_4N)$**, &c. &c. And, to a certain extent, the explanation may lie in the supposition, that the high temperature to which they are subjected brings about a partial decomposition or "**dissociation.**"

If one or **more** of the **atoms** of a **fully saturated molecule** be **removed**, it is obvious that the residue will be **no longer saturated**: such residues are called **Radicles.** In the case of the

tetrad Carbon, the saturated hydrogen compound is known as METHANE CH_4; the removal of one atom of hydrogen, leaves a residue known as METHYL CH_3. A further removal of an atom of hydrogen, leaves a bivalent radicle METHENE CH_2. If we take away three atoms of hydrogen from METHANE CH_4, we obtain the trivalent radicle METHENYL CH. Lastly, when all the hydrogen is removed, we have the **tetrad Carbou** remaining. So likewise with the saturated molecule **hydrogen oxide** or **water** OH_2; take away an atom of hydrogen, and we have a monad radicle HYDROXYL OH, analogous to chlorine, &c.

The **atomic weight** of an element is, then, in **some** cases **identical** with its equivalent; in **other** cases **equal** to **two, three, four, five** times, &c., its equivalent weight. In other words, one atom of an element may displace or be substituted for 1, 2, 3, 4, 5, 6 atoms of hydrogen. This difference in combining or saturating power is called **Atomicity** or **Quantivalence.**

The elements are **64** in number, and may be arranged according to their **quantivalence**. They are either **monads, dyads, triads, tetrads, pentads,** or **hexads**; either univalent, bivalent, trivalent, quadrivalent, quinquivalent or sexvalent. Elements of even equivalency are called **artiads**; of uneven, **perissads.**

ALPHABETICAL TABLE OF THE ELEMENTS, SYMBOLS, and ATOMIC WEIGHTS.

Aluminum	Al = 27.5	Gallium	Ga = 68
Argentum	Ag = 108	Glucinum	G = 9.3
Arsenicum	As = 75	Hydrargyrum	Hg = 200
Aurum	Au = 196.6	Hydrogenium	H = 1
Barium	Ba = 137	Iodine	I = 127
Bismuth	Bi = 210	Indium	In = 113.4
Boron	B = 11	Iridium	Ir = 198
Bromine	Br = 80	Kalium	K = 39.1
Cadmium	Cd = 112	Lanthanum	La = 139
Caesium	Cs = 133	Lithium	L = 7
Calcium	Ca = 40	Magnesium	Mg = 24
Carbon	C = 12	Manganesium	Mn = 55
Cerium	Ce = 138	Molybdenum	Mo = 96
Chlorine	Cl = 35.5	Natrium	Na = 23
Chromium	Cr = 52.2	Nickel	Ni = 58.8
Cobalt	Co = 58.8	Niobium	Nb = 94
Cuprum	Cu = 63.4	Osmium	Os = 199
Didymium	D = 144.75	Oxygenium	O = 16
Erbium	E = 168.9	Palladium	Pd = 106.5
Ferrum	Fe = 56	Phosphorus	P = 31
Fluorine	F = 19	Platinum	Pt = 197.1

ALPHABETICAL TABLE OF THE ELEMENTS, &c.—*continued.*

Plumbum	Pb = 207	Tellurium	Te = 129
Rhodium	R = 104.3	Thallium	Tl = 203.6
Rubidium	Rb = 85.4	Thorium	Th = 231.5
Ruthenium	Ru = 104.2	Titanium	Ti = 50
Selenium	Se = 79.5	Tungsten	W = 184
Silicium	Si = 28	Uranium	U = 120
Stannum	Sn = 118	Vanadium	V = 51.3
Stibium	Sb = 122	Yttrium	Y = 92
Strontium	Sr = 87.6	Zincum	Zn = 65.2
Sulphur	S = 32	Zirconium	Zr = 89.5
Tantalum	Ta = 182		

A. The Non-Metallic Elements.

1. Oxygen	O = 16	9. Sulphur	S = 32
2. Hydrogen	H = 1	[10. Selenium	Se = 79.5]
3. Nitrogen	N = 14	[11. Tellurium	Te = 128]
4. Carbon	C = 12	12. Boron	B = 11
5. Chlorine	Cl = 35.5	13. Silicon	Si = 28
6. Bromine	Br = 80	14. Phosphorus	P = 31
7. Iodine	I = 127	15. Arsenicum	As = 75
8. Fluorine	F = 19		

Selenium and Tellurium, which are bracketed, are of no importance except to students of Chemistry. Hydrogen is, properly speaking, a metal; but this division of the elements is only retained because of the requirements of certain Universities.

I. Oxygen O = 16. $O_2 = 32$. ✓

A dyad element. Colorless, tasteless and inodorous gas; uninflammable. A great supporter of combustion. Necessary to respiration, decay, germination, and the commencement of putrefaction. The most magnetic of gases: the diurnal variations of the needle referable to the effects of heat upon it. Oxygen is 16 × heavier than its own volume of hydrogen. One litre weighs 1.437 grammes; 11.19 litres weigh 16 grammes (one gramme is equal to 15.432 grains, and one litre to 1.76 pints). Compared with dry air it has a relative weight or specific gravity of 1.1056: one hundred cubic inches weigh 34.29 grains at 15°.5 C. and 30″ bar. In water it is very little soluble; 100 vols. dissolve 2.99 vols. at 15° C., and 4.11 vols. at 0° C. In the free state, or native, oxygen constitutes 21 per cent. by measure, and 23 per cent. by weight of dry air. Combined with Hydrogen, in the form of **Water** OH_2, it forms $\frac{8}{9}$ of the weight of the latter.

It is a constituent of most minerals, and of a great number of organic compounds.

When bodies are burnt in oxygen, they oxydize, and increase in weight. Thus at a temperature of 315°, Mercury (Hydrargyrum Hg) slowly oxydizes and becomes red in colour, and when further heated gives off oxygen again. Priestley in 1774 first prepared oxygen from MERCURIC OXIDE. *Prep.* 1. From **mercuric oxide** HgO, by heat: $2HgO = 2Hg + \mathbf{O_2}$. 2. From **manganese dioxide** MnO_2, by heat: MANGANOUS-MANGANIC OXIDE Mn_3O_4 remains. $3MnO_2 = Mn_3O_4 + \mathbf{O_2}$. One kilogramme (2.2 lbs., each pound of 7000 grains) of the ore will yield about 50 litres of oxygen. 3. From **barium dioxide** BaO_2, by heat; BARIUM OXIDE BaO remains. $2BaO_2 = 2BaO + \mathbf{O_2}$. 4. From **hydrogen oxide** $\mathbf{OH_2}$ by electrolysis; oxygen separates, because the electro-negative element, at the positive pole or platinode. 4. From **potassium** (kalium) **chlorate** $KClO_3$ by heat: POTASSIUM CHLORIDE KCl remains. $2KClO_3 = 2KCl + 3O_2$ (the chemical action is more correctly: 1. $2ClO_2OK = ClK + ClO_3OK + \mathbf{O_2}$. 2. $ClO_3OK = ClK + 2O_2$). [122.6 parts by weight of potassium chlorate will yield 48 parts by weight of oxygen. One hundred parts therefore: $122.6 : 100 :: 48 : x = 39.15$.] For other methods, see also HYDROGEN SULPHATE $SO_2(OH)_2$; MANGANESE DIOXIDE MnO_2; POTASSIUM DICHROMATE $Cr_2O_7K_2$; and POTASSIUM CHLORATE $ClO_2(OK)$, p. 20.

Ozone O_2O = 2 vols. An allotropic modification of oxygen, or oxygen under different physical and chemical aspects. By Schönbein. Best prepared by Siemens' induction coil, in action, upon oxygen. Also by moist phosphorus upon air or oxygen. Gas of peculiar metallic odor, insoluble in water, in alkaline and acid solutions. Absorbed by solution of potassium iodide KI. Irritates respiratory organs. Instantly decomposed at 290° into oxygen gas; two volumes into three. Is contained in minute quantities in pure air, but is instantly removed by putrescent matter. A grand oxydizing agent: bleaches also and disinfects. Iron, mercury, copper and iodine are oxydized by it, and so is also silver leaf if ozone moist. Best test for ozone is a paper soaked in solution of potassium iodide and starch: the liberated iodine blues the paper. Thus: $O_2O + 2KI + OH_2 = 2HOK + O_2 + I_2$.

II. Hydrogen H = 1. $H_2 = 2$.

A monad element: the standard of atomic weights. Colorless, tasteless and inodorous gas, at least when pure. Inflammable when heated in air or in oxygen, burning into **Hydrogen oxide or water** OH_2. The lightest of all gases. Its density as compared with air 0.0691. One litre weighs only 0.0896 of a

gramme; 11.19 litres weigh one gramme at 0°C., and 760 millimetres bar. 100 c. ii. weigh 2.14 grains. [The weight of one Litre 0.0896, or say 9 Centigrammes, is called a **Crith** by Hoffmann. In these "Notes," preference is given to Dr. Williamson's standard, the weight of one Gramme of Hydrogen = 11.19 litres.] Hydrogen, like oxygen, has never been liquefied. Water dissolves only 1.93 per cent at 15° C.

Meteoric iron generally contains Hydrogen, and indeed the latter constitutes the chief element in the atmosphere of a numerous class of stars. **H** penetrates iron and platinum tubes at a red-heat. Palladium foil condenses 643 times its volume of hydrogen below 100° C., and Palladium-sponge 90 vols. This absorption called **Occlusion**.

The **diffusive** power of Hydrogen is very high. The diffusive power varies inversely as the square root of the density of the gas. Thus the respective densities of hydrogen and oxygen are as 1 to 16; their relative rates of diffusion are as the square roots of these numbers. The rates of **Effusion** of gases, or the rate of passage through a minute aperture in a thin plate of metal or other substance into vacuum, follow the same law as their rates of diffusion.

Hydrogen is found chiefly in combination with oxygen in water and in nearly all organic compounds. It is separated from HYDROGEN OXIDE OH_2, either by electrolysis, or by the action of certain other metals possessed of a stronger affinity. *Prep.* of hydrogen. 1. From OH_2 by electrolysis: as a metal or the electro-positive element, $\mathbf{H}_2$ separates at the zincode or negative pole. 2. From WATER in the form of steam, when passed over red-hot iron; FERROUS-FERRIC OXIDE Fe_3O_4 remains. $Fe_3 + 4OH_2 = O_4Fe_3 + 4\mathbf{H}_2$. 3. From WATER by the action of NATRIUM (sodium) Na. SODIUM HYDROXIDE NaOH is found in solution. $Na_2 + 2OH_2 = 2NaOH + \mathbf{H}_2$. 4. By action of **zinc** upon HYDROGEN CHLORIDE ClH; ZINC CHLORIDE $ZnCl_2$ is found in solution. $Zn + 2ClH = ZnCl_2 + \mathbf{H}_2$. 5. Also by the action of ZINC upon HYDROGEN SULPHATE SO_4H_2 diluted with water: ZINC SULPHATE SO_4Zn remains. $Zn + SO_4H_2 + \text{water} = SO_4Zn + \text{water} + \mathbf{H}_2$.

Compounds of **H** with **O**.—1. HYDROGEN OXIDE $\mathbf{OH_2} = 18$. Water is a clear transparent fluid, colorless, but of a blue tint in mass. Below 0° C. it freezes and crystallizes in rhombohedra and in six-sided prisms. At 100° C., and Bar. 30" it boils, having a vapor possessed of the same elasticity as the air. Vapor-density compared with air 0.625, compared with H = 9. Increased pressure raises the boiling-point, and so does also the presence of a solid, &c. Maximum density at 4° C. Sp. gr. of ice 0.94. One litre of water at 4° C., weighs 1000 grammes. [One c.i. of water at 16°.6 C., weighs 252.456 grs., and a cubic foot 997

oz. avoirdupois. **N.B.** 437.5 grs. to one oz. and 7000 grs. to one lb. avoirdupois.] One imperial Gallon weighs 70,000 grs. or 10 lbs. avoirdupois. Water is 825 times heavier than air. Latent heat of water 79° C.; latent heat of steam at 100° C., 537° C. In the state of vapor, water consists of two vols. of H and one vol. of O condensed into two vols. Water is a great solvent of solids, liquids and gases, especially of the latter. As the air is a mixture, and the oxygen is more soluble than nitrogen, at 10° C. the ratio of admixture is 35 vols. of **O** to 69 of **N**. Many oxides unite with water to **Hydroxides** with great heat: thus, POTASSIUM HYDROXIDE OR HYDRATE **KOH**. Many salts (anhydrous) unite with water without alteration of atomic arrangement: **Water of Crystallization** which is easily removed by heat. **Cryohydrates** exist only below 0° C.; *e.g.* $NH_4Cl, 12OH_2$. Loss of water by a salt, **Efflorescence**; attraction of water, **Deliquescence.** Substances of great diffusibility called by Graham **Crystalloïds**; of low, **Colloïds.** Separation, by **Dialysis.** 2. HYDROGEN PEROXIDE $\mathbf{O_2H_2}$ or DI-HYDROXYL. A liquid of sp. gr. 1.453 discovered by Thénard in 1818. Resembles chlorine feebly. Begins to give off **O** at 20° C., and the whole at 100° C., being reduced to water. Bleaches litmus. Oxydizes black SPb to white SO_4Pb. Oxides of silver, gold and platinum, reduced to metals. SILVER OXIDE Ag_2O + HYDROGEN PEROXIDE O_2H_2 = $Ag_2 + OH_2 + \mathbf{O_2}$. One molecule of each is separated. Peroxides similarly evolve **O** and are reduced to lower oxides. This is well seen in the case of OZONE and HYDROGEN PEROXIDE: $O_2O + O_2H_2 = OH_2 + 2O_2$. *Prep.* From BARIUM PEROXIDE BaO_2 in presence of WATER and hydrogen chloride. $BaO_2 + OH_2 + 2ClH$ = BARIUM CHLORIDE $Cl_2Ba + OH_2 + \mathbf{O_2H_2}$.

III. Nitrogen N = 14. N_2 = 28.

Also called **Azote.** Triad element in ammonia H_3N: pentad in N_2O_5: monad in N_2O. Colorless, tasteless, inodorous gas: uninflammable; incombustible in air, and not a supporter of combustion. Discovered by Rutherford in 1772. [Lighter than air: 0.972. One hundred c.ii. at 0° C., weigh 30.935 grs.] 11.19 litres weigh 14 grammes. 100 vols. of water dissolve 2.03 vols. at 0° C., and 1.48 vols. at 15° C. Practically, **N** is one-half as soluble as **O**.

Atmospheric air is a MIXTURE of nitrogen with oxygen, in the ratio, when dry, of 79 vols. of **N** with 21 vols. of **O**. *Prep.* Dependent upon the easy removal of oxygen from air by combustion of phosphorus; or by passing air over red-hot copper, when copper oxide CuO remains. 2. By heating AMMONIUM NITRITE $\mathbf{NO(ONH_4)}$, when water and nitrogen alone result: $NO(ONH_4) = 2OH_2 + \mathbf{N_2}$. 3. Also by passing Chlorine gas through solution

of AMMONIA H_3N. Thus: $3Cl_2 + 2NH_3 = 6ClH + N_2$. 4. An alkaline solution of PYROGALLIC ACID $C_6H_6O_3$, may also be employed for removing oxygen from the air; see 'Organic Chemistry.' 5. By mixing air with hydrogen, and detonating with electric spark: EUDIOMETER.

Compounds. Nitrogen with hydrogen. AMMONIA $\mathbf{H_3N}$ or $\mathbf{NH_3}$ = 17. Colorless, irrespirable gas, of pungent odor, exciting to tears. Feebly combustible owing to the hydrogen with pale greenish flame. Alkaline reaction. Sp. gr. of gas compared with air 0.589. 11.19 litres weigh 8.5 grammes. Under pressure of 6.5 atmospheres at 15° C., into a colorless liquid. Very soluble in water and in alcohol. Water dissolves 1180 times its vol. at 0° C.; 898 times at 10° C., and 727 vols. at 15° C. Its solution in water is a valuable re-agent; the strongest has sp. gr. 0.88, contains 36 per cent. by weight, and boils at 54° C. Such solution, colorless, completely volatile, does not precipitate calcium hydroxide, nor argentum nitrate when super-saturated with hydrogen nitrate (absence of chloride), nor barium chloride (absence of sulphate). H_3N is produced in respiration, as well as in the decay and combustion of all nitrogenized bodies. *Prep.* From equal weights of AMMONIUM CHLORIDE ClH_4N, and CALCIUM OXIDE OCa: CALCIUM CHLORIDE Cl_2Ca, WATER OH_2 and AMMONIA $\mathbf{H_3N}$ result. $2H_4NCl + OCa = Cl_2Ca + OH_2 + 2\mathbf{H_3N}$. Slaked lime or calcium hydroxide CaO,OH_2 or CaH_2O_2 may also be used. [Students should accustom themselves to various modes of writing symbols.]

AMMONIA may unite directly with certain salts of hydrogen, as with HYDROGEN CHLORIDE HCl, to AMMONIUM CHLORIDE NH_4Cl, or to AMMONIA HYDROCHLORIDE NH_3HCl (4 vols.). In water it behaves like a HYDROXIDE $NH_4\mathbf{OH}$, in which hypothetical AMMONIUM NH_4 is united with HYDROXYL **OH.** **[Hydroxylamine** $\mathbf{NH_2OH}$ or NH_3O is intermediate. It may be formed by the direct union of NITROGEN OXIDE NO with H, and also by the action of H upon NITRIC ACID NO_2OH. Thus: $NO_2OH + 3H_2 = 2OH_2 + \mathbf{NH_2OH}$. Very volatile, decomposable base. Gives grass-green precipitate with cupric sulphate, and decolorizes ammoniacal cupric sulphate.]

Nitrogen with oxygen. 5 compounds: N_2O, N_2O_2, N_2O_3, N_2O_4, N_2O_5. [NITRIC ANHYDRIDE $\mathbf{N_2O_5}$. Right rhombic prisms, brilliant, colorless. Fuse at 85° C., boil at 113° C., and decompose. With OH_2 into hydrogen nitrate or nitric acid: $N_2O_5 + OH_2 = 2NO_2OH$. *Prep.* by CHLORINE upon ARGENTUM NITRATE NO_2OAg. Thus: $2Cl_2 + 4NO_2OAg = 4ClAg + O_2, + 2\mathbf{N_2O_5}$.] **Nitric acid or hydrogen nitrate $\mathbf{NO_2OH}$** or $\mathbf{HNO_3}$ = 63. The *aqua fortis* of the alchemists. Fuming, corrosive liquid of sp. gr. 1.52 at 15° C., boils at 85° C. By Cavendish in 1785. May be called a **salt** of **hydrogen** or of the radicle **hydroxyl,** as is the case with **all acids.** Freezes at −40° C.

Stains the skin yellow. An escharotic. Cannot be distilled without partial decomposition. Yellow color due to N_2O_3 in solution. MONOBASIC ACID, as it contains only one atom of displaceable Hydrogen **H**, or Hydroxyl **OH**. All its salts soluble in water, except trisnitrate of bismuth. When the acid of 1.52 is boiled, oxygen and nitrous anhydride are evolved, the boiling-point rises to 121° C, and an acid distils of composition approaching to $2NO_2OH,3OH_2$: not a true hydrate, but stable under ordinary pressures. Silver, copper, mercury, are changed into nitrates, with evolution of orange fumes, when heated with nitric acid. It bleaches solution of indigo in hydrogen sulphate, and in a free state browns solution of ferrous sulphate. *Prep.* from SODIUM NITRATE NO_2ONa by distillation with SULPHURIC ACID $SO_2(OH)_2$. Thus: $NO_2ONa + SO_2(OH)_2 = SO_2OHONa + NO_2OH$. Better from sodium than potassium nitrate, because at. weight of sodium is 23, and that of potassium is 39.1. POTASSIUM NITRATE NO_2OK is saltpetre. SODIUM NITRATE NO_2ONa is cubic nitre. AMMONIUM NITRATE, NO_2ONH_4 is used in making **nitrous oxide** ON_2. 2. NITROUS OXIDE, ON_2 or $N_2O = 44$. Also MONOXIDE or *laughing gas.* Colorless inodorous gas, of sp. gr. 1.527. Sweetish smell and taste. 100 vols. of water at 0° C. dissolve 130 vols. of the gas. Under pressure of 50 atmospheres at 7° C., reducible to a colorless liquid, which freezes at − 99° C., and boils at − 92° C. The gas supports combustion. Much used as anæsthetic in dentistry. By repeated heating into 2 vols. of N. and 1 vol. of O. When potassium heated in it, POTASS-OXIDE OK_2 and N_2 result. *Prep.* of the gas: 1. By heating AMMONIUM NITRATE NO_2ONH_4 above 230° C., it breaks up into water and nitrous oxide: $NO_2ONH_4 = 2OH_2 + ON_2$. 2. By dilute nitric acid upon zinc; zinc nitrate, water, and nitrous oxide result. $10NO_2OH + 4Zn + nOH_2 = 4[(NO_2)_2O_2Zn] + ON_2 + nOH_2 + 5OH_2$. 3. NITRIC OXIDE or NITROSYL $NO = 30$. A colorless gas of sp. gr. 1.039. Irrespirable, suffocating. Very stable. Supports burning of lighted phosphorus. Absorbed by Ferrous sulphate SO_2O_2Fe to olive-brown compound $2[SO_2(O_2Fe)],NO$. Neither acid nor alkaline. A test for free oxygen, with which it unites to NITROGEN TRIOXIDE N_2O_3, or NITROGEN PEROXIDE NO_2, according to the amount of oxygen employed, with production of orange-colored gas. *Prep.* of **NO**. By the action of Cu upon hydrogen nitrate: copper nitrate, water, and nitrosyl result. $3Cu + 8NO_2OH = 3[(NO_2)_2O_2Cu] + 4OH_2 + 2NO$. 4. NITROGEN TRIOXIDE, or NITROUS ANHYDRIDE N_2O_3. At − 18°, a thin, mobile blue liquid, which gives off orange vapors. At ordinary temperatures a vapor, prepared by mixing four volumes of **Nitrosyl** NO with one volume of oxygen $2NO + O = N_2O_3$.

Mixed with little water, into NITROUS ACID **$NO(OH)$**. Thus: $N_2O_3 + OH_2 = 2NO(OH)$. But, with more water, into nitric oxide or nitrosyl and nitric acid. $3N_2O_3 + OH_2 = 4NO + 2NO_2OH$. *Prep.* as above. [Also by nitric acid upon arsenious anhydride As_2O_3. Thus: $As_2O_3 + 2NO_2OH + 2OH_2 = 2[AsO(OH)_3] + N_2O_3$]. Ammonia becomes nitrous acid in contact with heated platinum or platinum black. Copper also effects the change in presence of air. Acidulated solutions of nitrites bleach permanganates. Nitrites detected by added hydrogen chloride with starch and potassium iodide. Dilute hydrogen sulphate, together with ferrous sulphate may be employed: immediate browning. 5. NITROGEN PEROXIDE **NO_2** $= 46$. In prismatic crystals, which melt at $-9°$ C. to a mobile liquid of greenish-yellow tint; boils at $22°$ C. Vapor red-brown, deepening with rise of temperature. Indeed, at low temperatures it is a TETROXIDE **N_2O_4**; at higher, above $154°$ C., a DIOXIDE OR PEROXIDE **NO_2**. Largely contained in the nitrous acid of commerce. Decomposed by little water, so as to yield nitric and nitrous acids, $2NO_2 + OH_2 = NO_2OH + NOOH$. By excess of water, into hydrogen nitrate and nitrosyl: $3NO_2 + OH_2 = 2NO_2OH + NO$. *Prep.* 1. By mixing 2 vols. nitric oxide with 1 vol. of oxygen $NO + O = NO_2$. 2. By heating LEAD NITRATE $(NO_2)_2O_2Pb$ to strong redness in a retort $2[(NO_2)_2O_2Pb] = 2OPb + O_2 + 4NO_2$.

IV. Carbon C = 12.

A tetrad element, whose natural condition is that of a solid body. Native in two dissimilar, **allotropic** modifications. 1. As **Diamond**, sp. gr. 3.33 to 3.55. In forms belonging to the regular system. Insoluble in all media and infusible. The hardest of all bodies, cut and polished by its own powder. Lustrous and of high refractive power. A non-conductor of electricity. Heated in voltaic arc, it swells up, resembles coke in appearance, and becomes a conductor of Electricity. 2. As **Graphite** or **Plumbago** of sp. gr. from 2.35 to 2.15. In powder known as black lead. Either massive, or in six-sided plates belonging to rhombohedral system: hence is Carbon **dimorphous**, as it crystallizes in two irreconcilable geometrical forms. Metallic lustre, friable, unctuous to the touch, and leaves black mark upon paper. Very hard. An excellent conductor of electricity. Used for protecting iron from rusting, and for lubricating machinery. When acted upon by nitric acid and potassium chlorate, into GRAPHIC ACID $C_{11}H_4O_5$; diamond, similarly treated, not acted upon. As **amorphous Carbon** or **lamp-black**, a third artificial variety of carbon must be mentioned. It is the basis of printing-inks, and is readily produced by the incomplete combustion

of resinous bodies, rich in carbon and hydrogen. It may also be considered the light-giving principle in flames. Wood-charcoal, coke and soot, are also impure varieties of carbon. Strongly antiseptic: **Cataplasma carbonis.** Decolorizing. All amorphous varieties of carbon, when heated with nitric acid and potassium chlorate, are dissolved to brown solutions.

Compounds. Carbon with **Hydrogen.** 1. ACETYLENE, or ETHINE C_2H_2 = 26. Colorless gas of peculiar odor, burning with smoky flame to carbonic anhydride CO_2 and water OH_2. Two vols., C_2H_2, requiring five vols. of O for complete combustion. *Prep.* A constituent of coal-gas, and always produced in the incomplete combustion of METHANE CH_4 and ETHENE C_2H_4. Also, by synthesis of its elements. 2. METHANE $CH_4 = 16$. Also called marsh-gas, light carbonetted hydrogen and fire-damp. Colorless, inodorous, tasteless gas, scarcely soluble in water. Inflammable, burning into OH_2 and CO_2, requiring twice its volume of oxygen and 10 × its volume of air. Is the first of the **paraffins**, see 'Org. Chemistry.' As to quantity, is most largely present in coal-gas. *Prep.* by heating SODIUM ACETATE CH_3COONa, with SODIUM HYDROXIDE HONa; SODIUM CARBONATE $CO(ONa)_2$ and METHANE CH_4 are alone produced. [Excess of Cl_2 in exposed light converts CH_4 into CCl_4 and 4HCl. Moist CH_4 and $4Cl_2(+2OH_2)$ in diffused light into $CO_2 + 8HCl$.] 3. ETHENE $C_2H_4 = 28$. Also ethylene, and olefiant gas. Colorless, transparent, of faint alliaceous odor. Liquefied under great pressure. Burns with white flame into CO_2 and OH_2. One vol. requires three vols. of **O** for complete combustion. $C_2H_4 + 3O_2 = 2CO_2 + 2OH_2$. Soluble in twelve times its bulk of water. Contained in coal-gas. *Prep. a.* From ETHINE C_2H_2 by nascent hydrogen. $C_2H_2 + H_2 = C_2H_4$. *b.* From ETHYLIC ALCOHOL C_2H_5OH, by a desiccator or dehydrant. $C_2H_5OH - OH_2 = C_2H_4$. [ETHENE C_2H_4 unites directly with Cl_2 to ETHENE DICHLORIDE $C_2H_4Cl_2$ or Dutch liquid. Colorless, aromatic liquid, of sp. gr. 1.28 at 0° C.] 4. BUTYLENE $C_4H_8 = 56$. Also, Oil-gas. Colorless gas, liquid at 0° C. **Polymeric** with ethene; the same percentage composition, with different condensation in the molecule. —**Carbon** with **Oxygen.** 1. CARBON OXIDE or CARBONIC OXIDE **CO** = 28. Transparent colorless gas, of sp. gr. 0.967. 100 vols. of water dissolve 3.28 vols. at 0° C., and 2.43 vols. at 15° C. Irrespirable; uninflammable. Burns with blue flame into CO_2. [Absorbed by K_2 at 80° C., and forms $K_2C_2O_2$. Solution of Cu_2Cl_2 also absorbs it, and forms CO, Cu_2Cl_2, $2OH_2$ in scales. As the residue of CO_2 after abstraction of O, it constitutes an important dyad radicle, CARBONYL **CO**, in organic bodies.] Contained in coal-gas, &c. *Prep. a.* By heating CO_2 with C = 2**CO**. *b.* By heating zinc or ferrum in CO_2. $Zn + CO_2 = ZnO +$ **CO**. *c.* By heating CO_2 and H_2 together: $= OH_2 +$ **CO**. *d.* By

heating OXALIC ACID $C_2O_2(OH)_2$ with a desiccator: $= OH_2 + CO_2 + \mathbf{CO}$. 2. CARBONIC ANHYDRIDE, or CARBON DIOXIDE $CO_2 = 44$. Colorless, transparent gas, of faint acidulous taste and smell. Sp. gr. 1.52. One hundred c.ii. weigh 47,445 grs. at 15°.5 C., and 30″ bar. Very injurious to life, but less so than carbon oxide. At 15°.5 C. water dissolves its own measure of the gas, and an additional volume for each additional atmosphere. As it is fully burnt, it is of course uninflammable; employed as an extinguisher of combustion. Under a pressure of 38.5 atmospheres at 0° C. into a colorless, limpid liquid, lighter than water; then into a snow-white solid by its own evaporation. It is contained in the air to the extent of 0.035 per cent.; in respired air to 3·5 per cent. Product of combustion of all bodies containing carbon, and a result of decay, germination, fermentation, and putrefaction. Its salts are called CARBONATES. No known combination with water, but hypothetical CARBONIC ACID $CO(OH)_2$ is a dibasic acid, containing two atoms of hydroxyl. Most carbonates are insoluble in water, and they all effervesce on the addition of most acids. *Prep.* *a.* By heating CALCIUM CARBONATE $CO(O_2Ca)$ or $CaCO_3$ to redness, it breaks up into CALCIUM OXIDE CaO and CARBONIC ANHYDRIDE $\mathbf{CO_2}$. *b.* By burning C in $O_2 = \mathbf{CO_2}$. *c.* By adding hydrogen nitrate to calcium carbonate: CALCIUM NITRATE $[(NO_2)_2O_2Ca]$, WATER OH_2 and CARBONIC ANHYDRIDE $\mathbf{CO_2}$ result. Thus: $2HNO_3 + CaCO_3 = Ca2NO_3 + OH_2 + CO_2$. CARBONIC ANHYDRIDE combines readily, and is therefore quickly absorbed by potassoxide or calcium oxide, or their hydroxides: *e.g.* $OK_2 + CO_2 = CO(OK)_2$. $KOH + CO_2 = CO(OK)(OH)$. $CaO + CO_2 = CaO,CO_2$.

Carbon and **Nitrogen**. CYANOGEN $\mathbf{C_2N_2} = 52$. Cyanogen is a colorless gas, of odor resembling peach-blossoms. Sp. gr. 1.8, or 26 when referred to H. Inflammable with color of peach-blossoms into CO_2 and N_2. One vol. requires 2 vols. of O for complete combustion. At 7°.2 C., under pressure of 3.6 atmospheres into colorless liquid. Water dissolves 4 × its volume. Always produced as a cyanide when various metallic oxides are presented at a red-heat to N or to nitrogenized compounds. *Prep.* *a.* Heating MERCURIC CYANIDE HgC_2N_2: into Hg, CYANOGEN C_2N_2 and PARA-CYANOGEN, a polymeric modification of cyanogen. *b.* Passing air over potassium carbonate mixed with charcoal and contained in a red-hot tube: $CO(OK)_2 + N_2 + 4C = 3CO + 2\mathbf{CNK}$. Then POTASSIUM CYANIDE **CNK**, with water and mercuric oxide OHg, gives potass-hydroxide and mercuric cyanide. Cyanogen, a good illustration of a radicle, or an unsaturated carbon residue. CARBON, a **tetrad**, united with **triad** NITROGEN, as **Cyanogen**, is a monad radicle. HYDROGEN CYANIDE **CNH**, is prussic acid, a mono-basic acid. A colorless, transparent liquid, very volatile, intensely poisonous: oppression and

constriction of fauces. Ammonia and water, best antidotes. Vapor inflammable. One vol. CN and one vol. of H united to 2 vols. in prussic acid. Potassium burns when heated in it, and displaces H. *Prep.* From POTASSIUM CYANIDE **CNK** by dilute sulphuric acid $SO_2(OH)_2$. Thus: $CNK + SO_2(OH)_2 =$ **CNH** + POTASSIUM HYDROGEN SULPHATE SO_2OHOK. See 'Organic Chemistry.'

V. Sulphur S = 32. S_2 = 64.

A dyad element, found native in Sicily and on the coasts of the Mediterranean. Pale-yellow, brittle, solid, of sp. gr. 2.045. Melts at 114°.5 C. into pale amber-colored liquid. Insoluble in water. Crystallizes from solution in Carbonic sulphide CS_2, as octahedron with rhombic base; the form of native sulphur. [It is also very soluble in SULPHUR DICHLORIDE S_2Cl_2. in BENZENE C_6H_6. and boiling TURPENTINE $C_{10}H_{16}$; little in ethyl alcohol C_2H_5OH, and still less in ether $C_4H_{10}O$, and in chloroform $CHCl_3$.] Heated beyond melting-point, darkens, thickens, and at 240° C., or so, is so tenacious that vessel may be upturned without loss. Then thin fluid again. and boils at 446° C. Sulphur sublimed; flowers of sulphur. Heated in air to 260° C. it burns with violet flame to SULPHUROUS ANHYDRIDE SO_2. Both allotropic and dimorphous. If native sulphur be melted and crystallized it separates in oblique prisms. Sp. gr. 1.98. Soluble in the same agents as the native. If either the native or prismatic variety (electro-negative) be heated to 250° C., or so, and poured into water, a third modification, the **amorphous** or **ductile** variety is obtained. Sp. gr. 1.957. Insoluble in all agents: electro-positive. Also a red and a black variety; the more frequently heated to 315° C., and cooled, the more of the black is obtained. Sulphur forms **sulphides** with the metals. IRON-PYRITES is Ferrous di-sulphide **FeS_2**. MAGNETIC PYRITES **Fe_7S_8**. COBALT-GLANCE **CoSAs**. NICKEL-GLANCE **NiSAs**. ZINC-BLENDE **ZnS**. GREENOCKITE **CdS**. GALENA **PbS**. SILVER-GLANCE **Ag_2S**. CINNABAR **HgS**. COPPER-PYRITES **$FeCuS_2$**. GREY ANTIMONY ORE or ANTIMONY-GLANCE **Sb_2S_3**. ORPIMENT **As_2S_3**. REALGAR **As_2S_2**. *Prep.* *a.* Native, by simple fusion from blue clay. Cast in moulds, as Tablund or prismatic Sulphur. *b.* Heating iron-pyrites in absence of air. $3FeS_2 = Fe_3S_4 + S_2$.

N.B.—Vapor of sulphur anomalous. Molecular volume below 816° C., S_6; above 1040° C., S_2; as compared with air, its vapor-volume is respectively 6.617 and 2.214.

Compounds. Of S with H. 1. HYDROGEN SULPHIDE **SH_2** = 34. Also sulphuretted hydrogen and rotten egg gas. Colorless gas, of offensive odor. Not irritant; narcotic. Sp. gr. 1.17. Water at 0° C., dissolves 4.37 times its volume; at 15° C., 3.23

vols. Solution feebly acid, reddens litmus, and is an important test. When SH_2 heated with tin, same volume of hydrogen remains as of gas. Burns with blue flame into water OH_2 and sulphurous anhydride SO_2. Three vols. of O required for complete combustion of SH_2. Blackens lead-paper. Under pressure of 17 atmospheres a liquid. Solid at $-86°$ C., boils at $-62°$ C. A constituent of Harrogate water. Emanates from sewers.

In acid solutions $\mathbf{SH_2}$ precipitates Pb, Cu, Cd, Hg, Ag, Au, Pt, Pd, Sb, As, Sn, and Bi, as sulphides. Thus: $SO_2O_2Cd + SH_2 + OH_2 = SO_2(OH)_2 + CdS,OH_2$. *Prep.* of $\mathbf{SH_2}$. *a.* From FERROUS SULPHIDE SFe by dilute sulphuric acid $SO_2(OH)_2$. $FeS + SO_2(OH)_2 + nOH_2 = SO_2(O_2Fe) + \mathbf{SH_2} + nOH_2$. *b.* From ANTIMONOUS SULPHIDE S_3Sb_2 and HYDROGEN CHLORIDE ClH, we obtain ANTIMONOUS CHLORIDE Cl_3Sb and $\mathbf{SH_2}$. Thus: $S_3Sb_2 + 6ClH = 2Cl_3Sb + 3\mathbf{SH_2}$. [**Hydrogen persulphide** $\mathbf{S_2H_2}$ $= 66$. An oily liquid, of yellow color, analogous to O_2H_2. Very unstable.] **Sulphur and Oxygen.** 1. **Sulphurous anhydride** or SULPHUR DIOXIDE $\mathbf{SO_2} = 64$. Colorless gas, pungent, irrespirable, suffocating; ever formed when S is burnt in air. Employed in bleaching flannel and straw, and as a disinfectant. Sp. gr. 2.21. 100 c.ii. weigh 68.69 grains. At $-17°.8$ C., liquid. Unites with OH_2 to SULPHUROUS ACID $\mathbf{SO(OH)_2}$ or $\mathbf{H_2SO_3}$. Forms a hydrate $\mathbf{SO(OH)_2,7OH_2}$. Soluble in water. 100 measures take up 68.8 measures at 0°, and 43.5 measures at 15°.5 C. Can be collected over mercury or by displacement. Decomposes SH_2. Thus: $10\mathbf{SO_2} + 10SH_2 = 2H_2S_5O_6 + 5S_2 + 8OH_2$. [Decomposes $KMnO_4$. Thus: $2KMnO_4 + 5\mathbf{SO_2} + 2OH_2 = K_2SO_4 + 2MnSO_4 + 2H_2SO_4$.] *Prep. a.* Burning **S** in air or in $\mathbf{O_2}$. *b.* Also by roasting iron-pyrites in air. $4FeS_2 + 11O_2 = 2Fe_2O_3 + 8\mathbf{SO_2}$. *c.* By boiling copper or mercury with sulphuric acid; mercuric sulphate, water, and sulphurous anhydride result. $Cu + 2SO_2(OH)_2 = SO_2O_2Cu + OH_2 + \mathbf{SO_2}$. *d.* By heating charcoal with sulphuric acid. $C + 2[SO_2(OH)_2] = CO_2 + 2OH_2 + 2\mathbf{SO_2}$. **Sulphites.** Sulphurous acid dibasic. Alkaline sulphites soluble. Ordinary acids decompose them. Reducing agents. 2. **Sulphuric anhydride** $\mathbf{SO_3} = 80$. In white, silken needles. Sp. gr. 1.946. Melts at 18°.3 C., and boils at 35° C. Great affinity for water. Soluble in all-proportions in $SO_2(OH)_2$. It is contained in Nordhausen sulphuric acid, a brown fuming liquid of sp. gr. 1·9. $\mathbf{SO_3}$ can be prepared by passing $SO_2 + O$ through red-hot tube filled with spongy platinum. Generally by heating almost dry ferrous sulphate, which gives *Nordhausen sulphuric acid* $SO_3,SO_2(OH)_2$, from which $\mathbf{SO_3}$ by gentle heat. Thus: $4(\mathbf{SO_4Fe}) + H_2O = 2Fe_2O_3 + 2SO_2 + \mathbf{SO_3,SO_2(OH)_2}$. 3. **Sulphuric acid** or **Hydrogen sulphate** H_2SO_4, $= 98$ or OH_2,SO_3 or $\mathbf{SO_2(OH)_2}$; the latter preferred, as it is a di-basic acid of first importance, and contains the dyad radicle

SO_2. "Oil of vitriol." Heavy liquid of sp. gr. 1.848. Solid at $-26°$ C. Boils and distils at 338° C. Chars organic bodies; great desiccator and dehydrant. Great affinity for water, forming two hydrates. $SO_2(OH)_2,H_2O$ of sp. gr, 1.78, freezes at 8°.3 C., hence glacial sulphuric acid. $SO_2(OH)_2,2H_2O$ a further hydrate, of 1.62 sp. gr. Used in making SO_2; NO_2OH; ClH; CO_2, &c. **Sulphates**; all soluble except of Barium, Strontium, and Lead. SODIUM SULPHATE $SO_4Na_2,10OH_2$, is "Glauber salt." BARIUM SULPHATE SO_4Ba is "Heavy spar." STRONTIUM SULPHATE SO_4Sr is "Celestine." MAGNESIUM SULPHATE $SO_4Mg,7OH_2$ is "Epsom salt." ZINC SULPHATE $SO_4Zn,7OH_2$ is "Zinc vitriol." CUPRIC SULPHATE $SO_4Cu,5OH_2$ is "Blue vitriol" LEAD SULPHATE SO_4Pb is "Lead vitriol.' **Prep. of oil of vitriol $SO_2(OH)_2$.** In leaden chambers. At the Felling works these are 280' long by 20' wide and 18' high. The essentials in the manufacture are: SO_2 : NO_2OH : H_2O and O_2 from the air. Simplest intelligible changes may be thus stated. *a.* $SO_2 + 2(NO_2OH) = SO_2(OH)_2 + 2NO_2$. *b.* $SO_2 + NO_2 + H_2O = NO + SO_2(OH)_2$. *c.* $NO + O = NO_2$. Thus a limited supply of nitric acid changes an almost unlimited amount of SO_2 into $SO_2(OH)_2$. The acid on the floor is the second hydrate somewhat diluted. By evaporation in leaden pans, it becomes first hydrate; beyond this point the concentration is conducted in vessels of glass or platinum, till, by the further loss of water, we obtain oil of vitriol, boiling at 333°, when the operation is stopped. 4. **Thiosulphuric acid $SSO(OH)_2$** $= H_2S_2O_3 = 114$. Unknown in free state, as on addition of an acid to one of its salts, it breaks up into $OH_2 + SO_2 + S$, which is precipitated. Formation of its sodium salt, by digesting solution of sodium sulphite $SO(ONa)_2$ with $S = SSO(ONa)_2$. SODIUM THIOSULPHATE $SSO(ONa)_2,5H_2O$ is the common hyposulphite of soda used in photography, and as antichlore for removing traces of chlorine from bleached goods. Dry salt, heated in close vessels; $4Na_2S_2O_3 = Na_2S_5 + 3Na_2SO_4$. [5. HYPOSULPHUROUS ACID $S(OH)_2$ or H_2SO_2. Orange-yellow, rapidly decomposing. Zn dissolves in solution of sulphurous acid, and affords a yellow solution of zinc hyposulphite. 6. **Dithionic acid $S_2O_4(OH)_2$** or $H_2S_2O_6 = 162$. Is more stable. Its manganous salt, by passing SO_2 through MnO_2 suspended in water $= S_2O_4O_2Mn$. If temperature allowed to rise, we obtain SO_2O_2Mn. **Dithionates** all soluble. When heated with an acid, SO_2 evolved, but no S is deposited. On concentration of the acid, it breaks up into $SO(OH)_2$ and $SO_2(OH)_2$. 7. TRITHIONIC ACID $S_3O_4(OH)_2$ or $H_2S_3O_6$. in prismatic crystals, easily decomposing into S, SO_2 and $SO_2(OH)_2$. Potassium salt, by potassium hydrogen sulphite with flowers of sulphur. 8. TETRATHIONIC ACID $S_4O_4(OH)_2$, readily breaks up, by boiling, into S_2, SO_2 and $SO_2(OH)_2$. 9. PENTATHIONIC ACID $S_5O_4(OH)_2$.

Unstable acid, prepared by passing a current of SH_2 through a solution of **sulphurous acid $SO(OH)_2$**. Thus: $10SH_2 + 10SO(OH)_2 = 5S_2 + 18OH_2 + 2S_5O_4(OH)_2$.]

So then we have: **Hyposulphurous acid $S(OH)_2$. Sulphurous acid $SO(OH)_2$. Sulphuric acid $SO_2(OH)_2$. Thiosulphuric acid $SSO(OH)_2$**, or sulphuric acid in which **S** displaces O. **Dithionic acid $S_2O_4(OH)_2$. Trithionic acid $S_2O_4S(OH)_2$. Tetrathionic acid $S_2O_4S_2(OH)_2$. Pentathionic acid $S_2O_4S_3(OH)_2$.** All dibasic, and containing two atoms of HYDROXYL **OH**.

Sulphur and Nitrogen. S_2N_2. Golden-yellow rhombs, insoluble in water. Explodes when heated to 157° C. Of faint odor and irritating. Obtained by passing dry NH_3 through solution of S_2Cl_2 in carbonic sulphide CS_2.

Sulphur and Carbon. *a.* **Carbonous sulphide CS** = 44. A brown powder, of sp. gr. 1.66. Insoluble in water, benzene, alcohol and ether, slightly in carbonic sulphide. *b.* **Carbonic sulphide CS_2** = 76. Transparent colorless liquid, of sp. gr. 1.272, of great refractive power. Boils at 83° C. Very inflammable, burns to CO_2 and SO_2. When pure (after long agitation with mercury) of ethereal odor: generally repulsive like cabbage water. Great solvent of sulphur, phosphorus, iodine, caoutchouc, oils, &c. Unites with metallic sulphides to **Sulphocarbonates.** *Prep.* of **CS_2**. By passing the vapour of S over red-hot charcoal contained in porcelain tube.

Sulphocarbonic acid $CS(HS)_2$ or **H_2CS_3**, answers to the presence of sulphoxyl instead of hydroxyl: from the ammonium salt by dilute acid. When CS_2 is heated with water in a sealed tube, into CO_2 and H_2S. With nascent H_2 into CSH_2 and SH_2. Exposed to light into CS and S which dissolves in CS_2. [**Carbon oxysulphide COS** is a gas of sp. gr. 2.104. soluble in its own volume of water. Absorbed by potasshydroxide as readily as CO_2, and liberated by weak acids. *Prep. a.* by direct combination of CO with S in vapor, in passage through red-hot tube. *b.* gently heating SO_3 with $CS_2 = S + SO_2 + \mathbf{COS}$. *c.* from hydrogen sulphocyanate by water: $\mathbf{CNSH} + OH_2 = NH_3 + \mathbf{COS}$.]

[VI. Selenium Se = 79.5. Se_2 = 159.]

Selenium is a dyad element in hydrogen selenide. SeH_2. By Berzelius in 1817. Never native. Greatest analogy to sulphur. A reddish-brown solid, of imperfect metallic lustre, somewhat translucent. Sp. gr. 4.3. Melts above 100° C, and boils at 343° C. Insoluble in water and in alcohol; slightly in CS_2. Soluble in sulphuric acid. Many allotropic varieties; odor, as of decayed horseradish when heated in air. **Selenium and Hydrogen. Hydrogen selenide SeH_2** = 81.5. Colorless,

inflammable gas, of very offensive odor. Soluble in water, and precipitates **Selenides** of metals. **Se and O. Selenious anhydride SeO_2** = 111.5. In snow-white needles. Either by burning Se in O or by nitric acid upon selenium. SELENIOUS ACID **$SeO(OH)_2$**, is readily reduced by $SO(OH)_2$, depositing Se. Also by Zn or Fe. Alkaline selenites soluble. SELENIC ACID $SeO_2(OH)_2$ = 145.5. Resembles sulphuric acid. Prepared from lead selenate by SH_2. **Carbonic selenide CSe_2.** A pungent liquid resembling CS_2.]

[VII. Tellurium Te = 128. Te_2 = 256.

Rarely native in Hungary. Discovered by Mueller in 1782, and by Klaproth, in 1798, named **Tellurium.** Chiefly as telluride of silver, gold, copper, bismuth and lead. Analogous to sulphur and selenium. Lustrous like silver; brittle. Rhombohedral crystals. Sp. gr. 6.26. Melts below red-heat. Bad conductor of heat and electricity. Burns when heated in O, with blue flame edged with green to TELLUROUS ANHYDRIDE TeO_2. **Hydrogen telluride TeH_2** = 130. Gas, of sp. gr. 4.53. Burns with blue flame. Soluble in water; reddens litmus, and oxydizes slowly depositing tellurium. Two sulphides. **TeS_2** and **TeS_3**. **Tellurous anhydride TeO_2** = 160. Fuses easily. Yellow whilst hot. When tellurium is boiled with NO_2OH, and then the solution poured into water, TELLUROUS ACID **$TeO(OH)_2$**, is deposited as a bulky powder. By heat into OH_2 and TeO_2. TELLURIC ACID **$TeO_2(OH)_2,2OH_2$** in striated, 6-sided prisms. By oxydation of tellurium with potassium nitrate, potassium tellurate is obtained. Whether as tellurite or tellurate, tellurium is thrown down from its solutions by Zn or Fe. Tellurates of alkaline metals reduced by Charcoal at a red-heat to **tellurides.]**

VIII. Chlorine Cl = 35.5. Cl_2 = 71.

Not native. Discovered by Scheele in 1774. Occurring in various chlorides. As potassium, sodium, calcium and magnesium chlorides in sea-water. Monad element, discovered by Scheele in 1774. Yellowish-green, χλωρὸς, gas, uninflammable, irrespirable, suffocating. (Antidotes: weak ammonia, and dilute alcohol.) Sp. gr. 2.47. 100 c.i. weigh 76.3 grains. Under pressure of 4 atmospheres at 15°.5 C., a yellow liquid of sp. gr. 1.33. Water dissolves 2.37 times its vol. at 15° C. Aqua chlorata. It also unites with water at 0° to a solid **hydrate $Cl_2 10OH_2$**. In presence of light, Chlorine decomposes water, with separation of oxygen. Its affinity for H and other

metals is very great. Many metals take fire in Cl gas: nearly all are tarnished, therefore Cl cannot be collected over mercury. **Chlorides** formed. Cl bleaches and disinfects: it decomposes at once many Hydrogen compounds. Thus: $2Cl_2 + 2SH_2 = 4HCl + S_2$. Again, in light: $2OH_2 + 2Cl_2 = 4ClH + O_2$. Hence also an oxydizing agent. Thus: $Cl_2 + SO_2 + 2OH_2 = 2ClH + SO_2(OH)_2$. All CHLORIDES soluble in water, except of SILVER **ClAg**, and LEAD **Cl_2Pb**. *Prep.* of **Chlorine.** *a.* by action of chloride of hydrogen ClH, upon manganese dioxide MnO_2. Thus: $MnO_2 + 4ClH$ = MANGANOUS CHLORIDE Cl_2Mn + WATER $2OH_2$ + CHLORINE **Cl_2**. *b.* by Weldon's process. MANGANOUS CHLORIDE $MnCl_2$, is precipitated by hot milk of lime or magnesia, and a stream of hot air blown through. First, manganous hydroxide is precipitated, and this with O from hot air converts manganous hydroxide into MANGANESE DIOXIDE MnO_2, united with the CALCIUM OXIDE CaO, or MAGNESIUM OXIDE MgO as **CaO,MnO_2** or **MgO,MnO_2**. When heated with hydrogen chloride, MAGNESIUM CHLORIDE $MgCl_2$, or CALCIUM CHLORIDE $CaCl_2$, together with WATER, are formed, and the further action as described above between $MnO_2 + 4ClH = Cl_2Mn + 2OH_2 +$ **Cl_2**. *c.* Deacon's process. By passing a mixture of hydrogen chloride and air over cupric sulphate heated to 370°–340° C. The action of the metallic salt one of contact-actions. *d.* From SODIUM CHLORIDE NaCl, MANGANESE DIOXIDE MnO_2 and SULPHURIC ACID $SO_2(OH)_2$. MANGANOUS SULPHATE SO_2O_2Mn. sodium sulphate $SO_2(ONa)_2$, WATER OH_2, and CHLORINE Cl_2 result. Thus: $MnO_2 + 2NaCl + 2SO_2(OH)_2 = SO_2(O_2Mn) + SO_2(ONa)_2 + 2OH_2 +$ **Cl_2**. **Compounds. Cl with H. Hydrogen chloride ClH.** Hydrochloric acid or muriatic acid. ClH = 36.5. Colorless, pungent, incombustible gas, of sp. gr. 1.269. 100 c.i. weigh 39.23 grains at 15°.5 C. Intensely acid taste. Under pressure of 40 atmospheres at 10° C., a colorless liquid. By condensing moisture, fumes in air. Very soluble in water, which at 0° C. takes up 500, and at 10° C. 472 times its vol. The solution in water long known. Sp. gr. of solution 1.22, is colorless, fuming, with 44 per cent. of the gas, answering to $ClH, 3OH_2$. No real hydrate. When heated, ClH is given off, sp. gr. sinks to 1.11, contains about 20 per cent. of the gas and may be distilled. This acid corresponds to $ClH, 8OH_2$, but is no true hydrate. The only true hydrate $ClH,2OH_2$, obtainable in crystals at low temperatures. Common muriatic acid is yellow from the presence of ferric chloride, and also contains sulphuric acid. The pure solution leaves no residue upon platinum. Silver nitrate NO_2OAg gives with Cl, ClH and other soluble chlorides a white curd-like precipitate of SILVER CHLORIDE AgCl, insoluble in NO_2OH, soluble in NH_3. *Prep.* of **ClH.** 1. By union of Cl and H, in equal volumes, in sunlight

or by a light. $Cl_2 + H_2 = 2ClH$. 2. From SODIUM CHLORIDE $ClNa$ by SULPHURIC ACID $SO_2(OH)_2$: $ClNa + SO_2(OH)_2 = SO_2OHONa + \mathbf{ClH}$. Action of **ClH** upon METALS. Upon **monads.** $K_2 + 2ClH = 2ClK + H_2$. Upon a **dyad.** $Mg + 2ClH = Cl_2Mg + H_2$. Upon **monad-oxides.** $K_2O + 2ClH = 2KCl + H_2O$. Upon **dyad-oxides.** $ZnO + 2ClH = ZnCl_2 + H_2$. Upon triad-oxides. $Fe_2O_3 + 6HCl = Fe_2Cl_6 + 3H_2O$. Upon tetrad-oxides. $SnO_2 + 4ClH = SnCl_4 + 2H_2O$. Action of **HCl** upon HYDRATES. $KOH + HCl = KCl + H_2O$. $BaO,OH_2 + 2HCl = BaCl_2 + 2OH_2$. $Fe_2O_3,3OH_2 + 6ClH = Fe_2Cl_6 + 6OH_2$. Upon PEROXIDES like MnO_2; PbO_2,—not basic. $4ClH + MnO_2 = 2OH_2 + MnCl_2 + \mathbf{Cl_2}$. **Aqua regia** or **nitro-muriatic acid** is a mixture of **HCl** with NO_2OH, evolving Cl_2, a great solvent of gold, platinum, &c., chlorides of which are thus obtained. **Chloro-nitric gas** $NOCl_2$, formed same time. $6ClH + 2NO_2OH = 2\mathbf{NOCl_2} + 4OH_2 + Cl_2$. Only $\frac{1}{3}$ of the Cl obtained. In chloro-nitric gas, Cl_2 takes the place of O in NO_2. Lemon-yellow gas, forming red, fuming fluid below $-7°$ C. **Chloro-nitrous gas NOCl**, by mixing NO with Cl, condensed into two vols. **Compounds** of **Cl** with **O.** *a.* **Hypochlorous anhydride** $\mathbf{OCl_2} = 87$. Gas of pale-yellow color, analogous to OH_2. Condensable into deep-red liquid. *Prep.* from mercuric oxide, by action of Cl_2. MERCURIC OXY-CHLORIDE $HgO,HgCl_2$ and $\mathbf{OCl_2}$ result. Thus: $2OHg + 2Cl_2 = OHg,Cl_2Hg + \mathbf{OCl_2}$. One vol. of water absorbs 200 vols. of OCl_2, and forms **Hypochlorous acid ClOH.** Yellow color, acid, and sweetish smell. Great bleaching agent. Decomposed by ClH. Thus: $ClOH + ClH = OH_2 + Cl_2$. **Hypochlorites.** *Prep. a.* by passing Cl_2 through hydroxides at low temperatures. $2HOK + Cl_2 = ClK + ClOK + OH_2$. *b.* by saturating ClOH with the respective metallic oxide. *c.* by distilling CALCIUM HYPOCHLORITE $Ca(OCl)_2$, with dilute sulphuric acid. $2Ca(OCl)_2 + SO_2(OH)_2 = Cl_2Ca + SO_2O_2Ca + 2\mathbf{ClOH}$. *d.* passing Cl_2 into water in which, say, calcium carbonate $CO(O_2Ca)$ is diffused. $2Cl_2 + OH_2 + CO_3Ca, = CO_2 + Cl_2Ca + 2\mathbf{ClOH}$. CHLORIDE OF LIME is *bleaching powder.* Consists mainly of CALCIUM OXY-CHLORIDE $\mathbf{Cl_2OCa}$ mixed with unaltered CALCIUM HYDROXIDE $(OH)_2Ca$. According to Kolb, it consists of $Ca_3H_6O_6Cl_4$, and is decomposed by water into CALCIUM HYPOCHLORITE $\mathbf{Cl_2OCa}$, CALCIUM CHLORIDE Cl_2Ca. CALCIUM HYDROXIDE $(OH)_2Ca + 2OH_2$. The dry chloride of lime gives up no CALCIUM CHLORIDE Cl_2Ca to alcohol: hence not contained, but produced by water. **HCl** can be changed into **HOCl** by nascent oxygen, derivable from $KMnO_4$. [*b.* **Chlorous anhydride** $\mathbf{Cl_2O_3} = 119$. Or $\mathbf{O(OCl)_2}$. Gas of deep greenish-yellow color, condensable to deep-brown mobile liquid. Water dissolves $10 \times$ its volume. Dangerous compound. *Prep.* action of HYDROGEN NITRITE $NO(OH)$ upon POTASSIUM CHLORATE

$ClOO(OK)$. Thus: $2NOOH + 2ClOO(OK) = 2NO_2OK + OH_2 + O(OCl)_2$. With water forms CHLOROUS ACID **$OCl(OH)$** or $HClO_2$. Addition of $As_2O_3 + NO_2OH$ to chlorites does not destroy their bleaching powers, as it does those of hypochlorites. *c.* **Chlorine peroxide, or dioxide ClO_2** = 67.5. Gas, of very deep yellowish-green color; at −20° C. a red fluid. Water dissolves 20 times its bulk. Explodes above 60° C. Must be collected by displacement. *Prep.* by action of SULPHURIC ACID (3) upon POTASSIUM CHLORATE (2) = $2ClO_2 + KClO_4 + OH_2 + 2(SO_2OKOH)$. *d.* CHLORIC ACID **$ClO_2OH$** = 84.5. Anhydride unknown. Syrupy liquid of faint chlorous odor. Very acid. Decomposed by organic matters. Monobasic. Easily prepared from BARIUM CHLORATE $Ba2ClO_3$, by dilute sulphuric acid. All chlorates soluble in water. When Cl_2 is passed into potassium hydroxide, and the temperature allowed to rise, water, chloride and chlorate of potassium result. $6HOK + 3Cl_2 = 3OH_2 + 5ClK + ClO_2OK$. When chlorate of potassium is heated to 370° C., it fuses, and is converted into potassium chloride KCl and O_2 by sufficient heat. $SO_2(OH)_2$ evolves ClO_2 with its peculiar odor. ClH evolves EUCHLORINE, a yellow explosive gas consisting of $2Cl_2O_5$, Cl_2O_3. [*e.* PERCHLORIC ACID **ClO_3OH** = 100.5. Colorless volatile liquid, and most powerful oxydizing agent. A hydrate $HClO_4.OH_2$ in white crystals. **Perchlorates.** Mostly deliquescent; all soluble. Potassium perchlorate with difficulty. All decomposed by heat into chlorides and oxygen. **ClO_3OK** easily prepared from ClO_2OK by stopping the evolution of O_2 when $\frac{1}{3}$ has passed over in the making of that gas. $2ClO_2OK = ClK + O_2 + ClO_3OK$. As ClO_3OK readily separated by crystallization from the very soluble chloride, PERCHLORIC ACID ClO_3OH is made by distilling the potassium salt with sulphuric acid.] [**Cl with N. Nitrogen chloride NCl_3**? Obtained indirectly. Oily liquid of sp. gr. 1.653. Most dangerous compound. Explodes spontaneously below 100° C. *Prep.* by action of Cl upon ammonium chloride $NH_4Cl + 3Cl_2 = 4ClH + NCl_3$.] **Cl with C.** C_2Cl_2, C_2Cl_4, C_2Cl_6 and CCl_4. 'Organic Chemistry.' **Carbonic oxy-chloride $COCl_2$**, is the phosgene gas of Davy. Carbon monoxide **CO**, unites in sunlight directly with **Cl_2**, volume for volume. Pungent, suffocating gas. Liquid at 0° C. Very interesting compound. [**Cl and S. Sulphur chloride S_2Cl_2** = 135. Yellow, volatile liquid of sp. gr. 1.68. Disagreeable, pungent odor. By passing dry Cl_2 into melted sulphur, and digestion upon sulphur. Slowly decomposed by water. **Sulphur dichloride SCl_2** = 103. Deep red, fuming liquid, boiling at 164° C. Produced by saturating S_2Cl_2 with Cl_2. **Sulphur tetrachloride SCl_4** by saturating the chloride with Cl_2 at −20° C. **Oxychlorides. $SOCl_2$ and SO_2Cl_2.**]

IX. Bromine Br = 80. Br_2 = 160.

Monad element, never native. Discovered by Balard in 1826. Closely allied to chlorine. Contained as magnesium and sodium bromide in sea-water, and largely in a spring at Kreuznach. Intensely red liquid, very volatile; freezes at $-24^\circ.5$ C., and boils at 63° C. Sp. gr. 2.976. Vapor intensely irritating, reminding of chlorine. Little soluble in water, more in alcohol, very soluble in ether. Hydrate **Br_2,10OH_2**. NO_2OH does not dissolve BrAg, and the latter, of yellowish color, is with difficulty soluble in NH_3. Otherwise **bromides** resemble chlorides. *Prep.* of **Br_2**. $MgBr_2 + Cl_2 = MgCl_2 + Br_2$. The bromine dissolved in ether, and treated with KOH. $3Br_2+6KOH = 5KBr + KBrO_3 + 3OH_2$. By heat $2KBrO_3 = 2KBr + 3O_2$. Then: $2KBr+MnO_2+3SO_2(OH)_2=SO_2(O_2Mn)+2(SO_2OKOH) +2OH_2+Br_2$. **Compounds. Br with H. Hydrogen bromide,** or hydro-bromic acid BrH = 81. Colorless gas. Its solution in water is a true hydrate **BrH,5OH_2**, a colorless fuming liquid of sp. gr. 1.486. Boils at 126° C., and distils. Oxydizes only in part on exposure to air. Solution decomposed by Cl_2. $2HBr + Cl_2 = 2ClH + Br_2$. Forms **bromides** and water, by contact with metallic oxides and hydroxides. *Prep. a.* By passing a stream of SH_2 through Br_2 diffused through water. $2Br_2 + 2SH_2 = S_2 + 4$**BrH**. *b.* Bringing phosphorous bromide into contact with water, and distilling. $PBr_3+3OH_2 = PHO(OH)_2 + 3$**BrH**. *c.* Decomposing potassium bromide KBr with hydrogen orthophosphate $PO(OH)_3$. $3KBr + PO(OH)_3 = PO(OK)_3 + 3$**BrH**. **Br with O.** [HYPOBROMOUS ACID **BrOH**. Unstable. Formed by agitating HgO with Br_2 and water.] BROMIC ACID **BrO_2OH** = 129. Resembles hydrogen chlorate. Best prepared from silver bromate by Br. *Bromates:* when heated, into O_2 and bromides. PERBROMIC ACID **BrO_3OH**. An oily liquid, made by the action of Br_2 upon hydrogen perchlorate. It resists the reducing action of SH_2 and SO_2. [Br and N. **Nitrogen bromide NBr_3**, oily liquid. **Carbonic oxy-bromide $COBr_2$**. **Br and S.** **S_2Br_2** and **SBr_2**, are brown-red liquids.]

X. Iodine I = 127. I_2 = 254.

Monad element, not found native. Discovered by Courtois in 1811 in kelp, the ash of sea-weeds. Occurs as sodium iodide in sea-water; also in various springs. Silver iodide AgI is one of the rarer silver ores. Iodine obtained by sublimation resembles black lead, and crystallizes as octahedron with rhombic base. Sp. gr. of vapour 8.716. Melts at 107° C., and boils at 175° C., the vapor possessing a deep violet, ἰώδης, color. Sp. gr. of iodine 4.95. Very little soluble in water, but easily in alcohol:

tincture of iodine. Stains the skin yellow. An energetic medicine. Cl_2 sets I_2 free from its soluble salts, and I_2 imparts a rich amethyst color to CS_2: a test. Free iodine forms blue compound with starch: also a test. IODIDES. Potassium iodide KI, much used in medicine. $2KI + 4NO_2OH = 2NO_2OK + 2NO_2 + 2OH_2 + I_2$. *Prep.* from SODIUM IODIDE NaI, in kelp, by SO_4H_2 and MnO_2, as in the making of Cl_2. Thus: $2NaI + MnO_2 + 3SO_2(OH)_2 = 2[SO_2(OH)(ONa)] + [SO_2(O_2Mn)] + 2OH_2 + I_2$. **Compounds. H** with **I.** [**Hydrogen iodide IH** = 128. Colorless gas, fuming in air, of sp. gr. 4.44. Very acid and irritating. Compressible to a liquid, and even solid at $-51°$ C. Very soluble in water: *hydriodic acid.* $2IH,11OH_2$ is the **hydrate.** Browns rapidly owing to oxydation of H_2. Decomposed by Cl_2,Br_2,NO_2OH. Dissolves Zn and Fe, evolving H_2. *Prep.* *a.* By heating I_2 in H_2. *b.* By passing SH_2 into H_2O, admixed with I_2. Thus: $2SH_2 + 2I_2 = S_2 + 4\mathbf{IH}$. *c.* By phosphorous iodide and H_2O. $PI_3 + 3H_2O = PHO(OH)_2 + 3\mathbf{HI}$. *d.* $8KI + P_4 + 10I_2 + 16OH_2 = 4[PO(OH)(OK)_2] + 28\mathbf{HI}$.] **I** with **O.** [Two anhydrides and two acids. $\mathbf{I_2O_3}$ and $\mathbf{I_2O_5}$: with OH_2 $\mathbf{IO_2,OH}$ and $\mathbf{IO_3OH}$. *a.* **Iodic acid $\mathbf{IO_2OH}$.** Colorless, 6-sided tables, very soluble in water. Decomposed by morphia, iodine set free: a test for morphia. Heated to 107° C. into $\mathbf{OH_2}$, and anhydride $\mathbf{I_2O_5}$. $2IO_3H = OH_2 + I_2O_5$. **Iodates**: by heat into iodides and oxygen. *Prep.* of $\mathbf{IO_2OH}$. *a.* By excess of Cl_2 upon I diffused through water; $I_2 + 5Cl_2 + 6OH_2 = 10ClH + 2\mathbf{IO_2OH}$. *b.* $5ICl_3$ + SODIUM CARBONATE $9[CO(ONa)_2] = 15NaCl + 9CO_2 + I_2 + 3IO_3Na$. A mixture of hydriodic and iodic acids instantly decompose one another: $5IH + IO_2OH = 3OH_2 + 3I_2$. *b.* **Per-iodic acid** IO_4H or IO_3OH. In deliquescent oblique prisms containing OH_2. Melts at 130°, then into OH_2 and **per-iodic anhydride** I_2O_7; then evolves O_2 and changed into I_2O_5, and finally into I_2+O_2. PERIODATES. *Prep.* $IO_2ONa + Cl_2 + 3NaOH = 2NaCl + NaO_4I,NaOH,OH_2$, the latter a sparingly soluble compound.] **I** and **N.** [**Nitrogen iodide** NHI_2 and NI_3. Black insoluble powder, explosive, dangerous. *Prep.* Precipitation of alcoholic solution of iodine by ammonia. $3NH_3 + 2I_2 = 2NH_4I + \mathbf{NHI_2}$. Decomposed by SH_2. $NHI_2 + 2SH_2 = NH_4I + S_2 + IH$.] **I** and **S.** $\mathbf{S_2I_2}$ crystalline, brittle, steel-grey solid.

XI. Fluorine F = 19. $F_2 = 38$.

Monad element, never native. Supposed to be a colorless gas, when prepared by the action of IODINE upon SILVER FLUORIDE AgF. Two chief **fluorides** found native are: **Calcium fluoride** CaF_2, or Fluorspar, and **Sodium aluminum fluoride** $3NaF,AlF_3$ or Cryolite. **Compounds. F** with **H.** HYDROGEN FLUORIDE or HYDROFLUORIC ACID FH = 20. Colorless, mobile liquid of

sp. gr. 0.988, which boils at 19°.4 C. Fuming, highly corrosive. Dangerous. The acid of sp. gr. 1.15 is a hydrate **FH,2OH₂**. boils at 120° C. **Etches** glass, owing to Fluorine forming with Silicon a volatile gaseous compound, **silicon fluoride** SiF_4. Thus: $SiO_2 + 4FH = 2OH_2 + SiF_4$. *Prep.* of **HF**. CALCIUM FLUORIDE is distilled with SULPHURIC ACID in vessels of lead or silver, and the acid is received and preserved in vessels of lead, silver, platinum, or gutta-percha. $F_2Ca + SO_2(OH)_2 = SO_2(O_2Ca) + 2FH$.

XII. Boron B = 11. $B_2 = 22$.

A triad element, never native. Contained in Borax. Always in combination with oxygen. By Gay-Lussac and Thénard in 1808. Amorphous boron, a dull-greenish powder, which soils the fingers, and is slightly soluble in water. NO_2OH attacks and dissolves it as boracic acid. It burns vividly into BORACIC ANHYDRIDE B_2O_3, when heated in oxygen. *Prep.* by heating **potassium boro-fluoride** KF,BF_3 with the metal **potassium** in a small iron vessel, and removal of the soluble POTASSIUM FLUORIDE by water. $2[KF,BF_3] + 3K_2 = 8KF + B_2$. There is also a crystalline variety of boron. Nearly colorless or brown, sp. gr. 2.63. Always contains ALUMINUM BORIDE B_2Al. Very hard: scratches the ruby. Acids have no action upon it. Infusible, and only partially combustible in oxy-hydrogen. *Prep.* by dissolving amorphous boron in fused aluminum at a high temperature, and removal of aluminum by hydrogen chloride. **Compounds. B** and **O**. **Boracic anhydride** B_2O_3, = 70. Issues as **boracic acid** $BO(OH).H_2O$ with jets of steam in the maremma of Tuscany. Fuses to transparent glass, which remains clear on cooling. *Prep.* by heating boracic acid to redness. Volatilized with great difficulty, hence it drives out many salt-radicles when heated with their salts. **Boracic acid** $BO(OH),OH_2$ or HBO_2,OH_2. In pearly scales, soluble in 25 parts of water at 18° C., and in 3 parts of boiling water. Turns turmeric paper brown. Soluble in alcohol and gives green color to flame. **Borates** are its salts: all soluble in NO_2OH. Chief salt: BORAX or SODIUM BI-BORATE $Na_2O,2B_2O_3$ or $Na_2B_4O_7,10OH_2$, which is found native. Dissolved in water, it is decomposed by dilute sulphuric acid, and furnishes boracic acid. **B** and **N**. [**Boron nitride** $BN = 25$. White amorphous powder, insoluble in water. In current of steam, yields $NH_3 + B_2O_3$. Obtained by heating B in N, or better, borax with ammonium chloride. $Na_2O,2B_2O_3 + 2NH_4Cl = B_2O_3 + 2NaCl + 4H_2O + 2BN$.] **B** and **Cl**. [**Boron chloride** $BCl_3 = 117.5$. Colorless, mobile liquid, of sp. gr. 1.35, boiling at 18° C. Decomposed by water into boracic and hydrochloric acids: hence fumes in air. *Prep.* by heating mixture of B_2O_3

and charcoal to bright redness, and passing a stream of dry Chlorine over it.] **B** and **F**. [**Boron fluoride** $BF_3 = 68$. A colorless gas, irritating, fuming. Water dissolves 700 times its volume, producing a fuming liquid of sp. gr. 1.77. The elements of water make it into $B_2O_3,6HF$, really the character of the solution. *Prep.* of $\mathbf{BF_3}$. By igniting a mixture of calcium fluoride with boracic anhydride. $5CaF_2 + 4B_2O_3 = 3Ca2BO_2 + 2\mathbf{BF_3}$. When BF_3, dissolved in much water, fluoboric acid $\mathbf{HF,BF_3}$, is obtained with free boracic acid. $8BF_3 + 6OH_2 = 2(BO_2H,OH_2) + 6(HF,BF_3)$. Boron made from POTASSIUM BOROFLUORIDE KF,BF_3, by heating with K.]

XIII. Silicon Si = 28.

Tetrad element, never native. Discovered by Berzelius in 1823. Combined with oxygen, silicon forms silica or silicic anhydride, one of the most abundant minerals. Like boron, two distinct modifications of silicon are known. *a.* **Amorphous silicon.** Brown powder, insoluble in, and denser than, water. A non-conductor of electricity. Soils the fingers. Intact in nitric or sulphuric acids: readily removed as gaseous **Silicon fluoride** by **Hydrogen fluoride**. Burns brilliantly when heated in air. *Prep.* by heating **Potassium** with **Potassium silico-fluoride**: $2(KF,SiF_4) + 4K_2 = 10KF + \mathbf{Si_2}$. *b.* **Crystalline silicon.** Steel-grey, metalline, and a conductor of electricity. Sp. gr. 2.49. Not attacked when fused with NO_2OK or ClO_2OK. Heated in Cl_2, into $SiCl_4$; in a stream of ClH into **Silicon-chloroform** $SiHCl_3$ and hydrogen. *Prep.* by heating in a red-hot crucible a mixture of potassium silico-fluoride, sodium and granulated zinc: the liberated Si dissolves in the zinc. The latter is removed by ClH. **Compounds.** **Si** and **H.** [**Silicon hydride** $SiH_4 = 32$. Colorless gas, which only takes fire spontaneously in air when free H is present. Passed through a red-hot tube, it is decomposed into Si and $2H_2$. Impure it is obtained from magnesium silicide and ClH; always accompanied by free H.] **Si** and **O**. **Silicic anhydride** or **Silica** $SiO_2 = 60$. In two modifications, crystalline and amorphous. As "rock-crystal," in 6-sided, transversely striated prisms, terminated by 6-sided pyramids. Sp. gr. 2.69. Insoluble in water, and in all acids, except hydrogen fluoride, which volatilizes the silicon as fluoride. Amethyst, cairngorm, agate, flint, carnelian, onyx, chalcedony, are varieties more or less pure of quartz, or silica. Opal contains about 10 per cent. of water. Fusible in oxy-hydrogen. Amorphous silica is a fine, white, tasteless powder, obtainable from either of the hydrogen silicates by a gentle heat. When once heated to redness, FH is its only solvent, by decomposition. Composition of the hydrates of silica doubtful. $\mathbf{OH_2,3SiO_2}$ and $\mathbf{OH_2,4SiO_2}$. **Silicates.** Clay, felspar, mica, &c.,

are silicates. **Metasilicates** represented by formula H_2SiO_3 or $SiO(OH)_2$; **orthosilicates**, by H_4SiO_4 or $Si(OH)_4$. Hydrates of silica are soluble in water. At a red-heat SiO_2 is one of the most powerful of the acids, as it is not volatile, and takes the place of the volatile salt-radicles in their respective salts. Potassium sulphate and silica strongly heated give potassium silicate as the residue. GLASS is generally a mixture of certain silicates (see GLASS). **Si and N.** [**Silicon nitride** formed by heating Si in N. A light bluish fibrous compound.] **Si and S.** [**Silicon sulphide** SiS_2. White, earthy, solid; deliquescent. Decomposed by water into $2SH_2$ and SiO_2. By heating Si in S vapor, SiS_2 is formed.] **Si and Cl.** **Silicon chloride** $SiCl_4 = 170$. Transparent, colorless liquid, pungent, irritating. Sp. gr. 1.523. Decomposed by water into ORTHOSILICIC ACID $Si(OH)_4$, and $4HCl$. *Prep.* by strongly heating a mixture of silica and charcoal, and passing a stream of Cl_2 over it: $SiO_2 + 2Cl_2 + C_2 = 2CO + SiCl_4$. **Silicon-chloroform** $SiHCl_3$ mixed with $SiCl_4$ constitutes CHLORO-LEUKON $Si_3H_4Cl_{10}$. **Si and Br.** [**Silicon bromide** $SiBr_4$. A liquid of sp. gr. 2.813. Similarly prepared and of similar behavior to $SiCl_4$.] **Si and I.** [**Silicon iodide** SiI_4. In colorless, transparent octahedra, which melt at 120°.5 C. From Si and I at high temperatures. Also **Silicon sesqui-iodide** Si_2I_6.] **Si and F.** **Silicon fluoride** $SiF_4 = 104$. Colorless gas of sp. gr. 3.6, fuming strongly in moist air. Uninflammable. Condensable to a liquid, which is solid at $-140°$ C. Must be collected over water, as it is in part decomposed by the latter. *Prep.* heating CALCIUM FLUORIDE CaF_2, together with SILICA SiO_2 and SULPHURIC ACID in a dry flask, and collecting over mercury. $2CaF_2 + 2SO_2(OH)_2 = 2SO_2O_2Ca + 4HF$. Then: $4HF + SiO_2 = 2OH_2 + SiF_4$. **Hydrogen silico-fluoride** $2HF,SiF_4 = 144$. A sour, fuming liquid. If it attacks glass, it is because SiF_4 volatilizes from it, and leaves HF. Action of water upon SILICON FLUORIDE SiF_4. $3SiF_4 + 4OH_2 = Si(OH)_4 + 2[2HF,SiF_4]$ Orthosilicic acid can be removed by filtration, and is thus easily obtained pure.

XIV. Phosphorus $P = 31$. $P_4 = 124$.

A triad element, never native. A constituent of the bones of vertebrata, of blood and urine, &c. In primitive and volcanic rocks, in an oxydized form. Discovered by Brandt in 1669. Called **Phosphorus** from its luminosity in air (from φῶς light, φορὸς bearer). Phosphorus is a translucent body, resembling wax, and, from oxydation, with a garlic smell. Brittle at low temperatures, it may be cut with a knife. Sp. gr. 1.83. Melts at 44° C., to a transparent liquid; boils at 208° C. 100 c.ii. of the vapor weigh 135 grains. It is insoluble in water, slightly

soluble in ether, but more so in benzene, turpentine and other oils. In CS_2, in S_2Cl_2 and in PCl, it is freely soluble and may be obtained crystallized in rhombic dodecahedra. It is a non-conductor of electricity. When slowly oxydized, it gives rise to PHOSPHOROUS ANHYDRIDE P_2O_3: in active, full combustion, to PHOSPHORIC ANHYDRIDE P_2O_5. If one volume of H encloses one atom, one volume of phosphorus in vapor encloses two atoms: the molecules, of two volumes, therefore, four atoms. 11.19 litres weigh 62 grammes. Phosphorus affords one of the most interesting illustrations of allotropism.—If common or vitreous phosphorus be exposed to light under water, it becomes **white**, opake, less fusible and of sp. gr. 1.515; it is re-converted into the vitreous at a temperature below 50° C.—A third variety is obtained by suddenly cooling melted phosphorus. This is **black** and opake, but becomes vitreous by simple fusion and slow cooling.—A fourth, or **viscous** variety, by heating very pure phosphorus to near its boiling-point and suddenly cooling.—The fifth is the most important variety, as it is not poisonous, and need not be kept under water, as it does not inflame below 260° C. First obtained by sublimation of Phosphorus in the Torricellian vacuum by exposure to sunlight. It is now largely prepared by heating vitreous phosphorus in an atmosphere of carbonic anhydride for 30 or 40 hours at a temperature of 230°C. to 240° C. A **red powder** of sp. gr. 2.14. Insoluble in all media. Crystallizes in rhombohedra. At 260° C. inflames and burns to P_2O_5. In Cl_2 it burns, as does the vitreous, and it detonates when rubbed with ClO_2OK. Used in Bryant and May's, and Bell and Black's matches. *Prep.* of **common phosphorus**. CALCIUM ORTHO-PHOSPHATE $(PO_4)_2Ca_3$ is changed by SO_4H_2 into CALCIUM SUPERPHOSPHATE $[(PO_4)_2H_4Ca]$ and CALCIUM SULPHATE SO_4Ca. Thus: $(PO_4)_2Ca_3 + 2SO_4H_2 = 2SO_4Ca + (PO_4)_2H_4Ca$. The superphosphate is filtered off from the nearly insoluble SO_4Ca, is mixed with charcoal, dried, and heated to redness. The SUPERPHOSPHATE $(PO_4)_2H_4Ca$ by loss of $2OH_2$ becomes CALCIUM METAPHOSPHATE $(PO_3)_2Ca$. And this metaphosphate heated to whiteness in an earthen retort with charcoal, gives calcium pyrophosphate, carbon oxide and **Phosphorus**. Thus: $4[(PO_3)_2Ca] + 10C = 2[P_2O_7Ca_2] + 10CO + P_4$. The phosphorus is received in water. **Compounds**. **P** with **H**. Three compounds H_3P; H_4P_2 and H_2P_4, a gas, a liquid, and a solid. *a*. **Phosphorus hydride** or **Phosphine** $H_3P = 34$. Colorless gas of strong garlic odor. Very inflammable, burning into water and phosphoric anhydride. 4 vols. require 8 vols. of O for complete combustion. Very little soluble in water. Behaves like ammonia and unites with IH to IODIDE OF PHOSPHONIUM H_4PI. *Prep.* *a*. distilling PHOSPHOROUS ACID $PHO(OH)_2$. Thus: $4PHO(OH)_2 = 3PO(OH)_3 + H_3P$.—*b*. boiling phosphorus with

a solution of potassium hydroxide. $P_4 + 3KOH + 3OH_2 = 3PH_2O(OK) + H_3P$. **N.B.**—In this process, the presence of liquid H_4P_2, renders phosphine spontaneously inflammable. Can be separated by a freezing mixture. CALCIUM HYDROXIDE may also be used, and calcium hypophosphite obtained at same time $2P_4 + 3Ca(OH)_2 + 6OH_2 = 3P_2O_2H_4O_2Ca + 2H_3P$. [$H_3P$ reduces silver-salts, $H_3P + 4OH_2 + 8NO_2Ag = 4Ag_2 + 8NO_2OH + PO(OH)_3$. Precipitates cupric phosphide $2H_3P + 3SO_4Cu = 3SO_4H_2 + Cu_3P_2$.] With IH, H_3P unites to form a crystalline compound PH_4I, an IODIDE OF PHOSPHONIUM. **P and O.** Two anhydrides: P_2O_3 and P_2O_5, forming phosphites and phosphates of hydrogen and other metals. 1. [**Hypophosphorous acid $PH_2O(OH)$**, a syrupy liquid, apt to absorb oxygen, and therefore a deoxydizing agent. Immediately reduces potassium permanganate. Hypophosphites all soluble. By heat into orthophosphoric acid $PO(OH)_3$ and phosphine H_3P. From barium hypophosphite by dilute sulphuric acid, we obtain the acid or hydroxyl salt.] 2. **Phosphorous anhydride** $P_2O_3 = 110$. White powder, volatile, deliquescent, inflammable. By slow combustion of phosphorus in dry air. **Phosphorous acid or hydrogen phosphite** $PHO(OH)_2$. Crystalline deliquescent substance prone to further oxydation. **Phosphites**, neutral and acid, as di-basic. [In a free state does not immediately reduce potassium permanganate. Reduces sulphurous acid to hydrogen sulphide with deposit of S by reaction upon the $SO(OH)_2$, and raises itself to orthophosphoric acid.] *Prep.* by adding water to phosphorous chloride, and removal of hydrogen chloride by heat. Thus: $PCl_3 + 3OH_2 = 3ClH + PHO(OH)_2$. 3. **Phosphoric anhydride P_2O_5** $= 142$. Snow-white, flocculent, deliquescent powder, fusible and volatile at a white heat. Great affinity for water; powerful desiccator, surpassing all others. Forms with water three acids or salts of hydrogen, mono-, tri-, and tetra-basic. *a.* **Ortho-phosphoric acid $PO(OH)_3$**, or tri-hydrogen phosphate, is the common phosphoric acid H_3PO_4 as it is often written. Crystalline. Tri-basic. Obtained by boiling P_2O_5 with water, or by boiling meta-phosphoric acid PO_2OH with OH_2. "Bone-earth," from which phosphorus is made, is Calcium ortho-phosphate $(PO_4)_2Ca_3$. **Phosphates**: all insoluble but those of alkaline metals. $PO(OAg)_3$ is yellow, and soluble in NO_2OH, as well as in H_3N. SH_2 readily separates orthophosphoric acid from lead or silver ortho-phosphate. $2PO_4Ag_3 + 3SH_2 = 3Ag_2S + 2PO_4H_3$. *b.* **Pyrophosphoric acid or hydrogen pyrophosphate $P_2O_3(OH)_4$** or **$P_2O_7H_4$**. Can be obtained in crystals. Silver pyro-phosphate is white. *Prep.* When orthophosphoric acid is heated to over 213° C., it loses OH_2 and becomes pyrophosphoric acid. $2PO(OH)_3 = OH_2 + P_2O_3(OH)_4$. Also, when di-sodium hydroxyl orthophosphate is heated to low redness, it loses OH_2 and on re-dis-

solving, gives sodium pyrophosphate. $2[PO(OH)(ONa)_2] - OH_2 = P_2O_3(ONa)_4$. A pyro-phosphate, decomposed by sulphuric acid, yields orthophosphoric acid on boiling. Ordinary phosphoric acid is precipitated as MAGNESIUM-AMMONIUM ORTHOPHOSPHATE, calcined and weighed as **magnesium pyrophosphate** $P_2O_3O_4Mg_2$, 100 parts of which contain 63.96 per cent. of P_2O_5. 3. **Metaphosphoric acid, glacial,** or **hydrogen metaphosphate** PO_2OH or PO_3H = 80. Results from heating either ortho- or pyro-phosphoric acid to redness. *Prep.* $PO(OH_3)$ by heat = $OH_2 + PO_3H$. A substance resembling ice, very deliquescent and sour. Monobasic. Precipitates albumen. **Metaphosphates.** Silver metaphosphate, white. When boiled with water, meta-phosphoric acid gives orthophosphoric acid. **Phosphorus oxide** P_4O = 140. A red powder, always formed in the incomplete combustion of phosphorus. **P and N.** [**Phospham** HN_2P contains H in addition. Yellowish-white, bulky powder. Obtained by heating $PCl_3,5H_3N$ in a current of carbonic anhydride.] **P and S.** [Six compounds are known. P_2S_3 and P_2S_5 are the analogues of the respective oxygen compounds. The compounds P_2S, P_2S_3 and P_2S_5 form sulphur salts with metallic sulphides.] **P and Se.** [Three selenides known P_2Se, P_2Se_3 and P_2Se_5.] **P and Cl.** 1. **Phosphorous chloride** PCl_3 = 137.5. Colorless, fuming liquid, very volatile. Sp. gr. 1.45. Boils at 73°.8 C. Great solvent of phosphorus. Immediately decomposed by much water into hydrogen chloride and phosphorous acid. $PCl_3 + 3OH_2 = 6ClH + POH(OH)_2$. *Prep.* by passing dry Chlorine into melted phosphorus in excess. 2. **Phosphoric chloride** PCl_5 = 238.5. White, crystalline solid, volatile below 100° C. Very deliquescent. Easily prepared by saturating PCl_3 with Cl_2. By a large excess of water, it is instantly decomposed into hydrogen chloride and orthophosphoric acid. Thus: $PCl_5 + 4OH_2 = 5ClH + PO(OH)_3$. **Phosphoric oxy-chloride** or **phosphoryl chloride** $POCl_3$ = 153.5. Limpid, volatile, fuming liquid, much used in chemical research. Boils at 110° C. *Prep. a.* from phosphoric chloride with little water. $PCl_5 + OH_2 = 2ClH + POCl_3$. *b.* By heating phosphoric chloride with phosphoric anhydride. $P_2O_5 + 3PCl_5 = 5POCl_3$. *c.* By heating phosphoric chloride with crystallized boracic acid. $3PCl_5 + 2(BOOH,OH_2) = 6ClH + B_2O_3 + 3POCl_3$. *d.* By passing O into boiling PCl_3. [**Phosphoric sulpho-trichloride** $PSCl_3$ = 169.5. Fuming, colorless liquid. Boils at 257° C. *Prep* by decomposing phosphoric chloride PCl_5 with SH_2. $PCl_5 + SH_2 = 2ClH + PSCl_3$. Or, by adding antimonous sulphide to phosphoric chloride. $Sb_2S_3 + 3PCl_5 = 2SbCl_3 + 3PSCl_3$. When heated with sodium hydroxide, sulphoxyphosphate is formed; $PSCl_3 + 6NaOH = 3NaCl + 3OH_2 + PS(ONa)_3$.] **P and Br.** [**Phosphorous bromide** PBr_3. Liquid, boils at 175°.3 C. **Phosphoric bromide** PBr_5. **Oxy-bromide** $POBr_3$.] **P and I.** [**Din-**

iodide of phosphorus, PI_2 = 285. In prismatic crystals of orange color. Melts at 110° C. By dissolving P in CS_2, and adding iodine. **Phosphorous iodide PI_3** Dark red, 6-sided plates. Fuses at 50° C.]

XV. Arsenicum As = 75. As_4 = 300.

A triad element, sometimes found in a free state, but chiefly in combination. MISPICKEL **FeSAs**; TIN-WHITE COBALT **$CoAs_2$**; COBALT-GLANCE **CoSAs**; NICKEL-GLANCE **NiSAS**; KUPFERNICKEL **NiAs**; ARSENICAL NICKEL **$NiAs_2$**; REALGAR **As_2S_2**; ORPIMENT **As_2S_3**.

The vapor-density of arsenicum, compared with that of H, is 150, which is twice its atomic weight, so that its molecule (like that of P) occupies as vapor only half the volume of a molecule of H. 11.19 litres of arsenicum weigh 150 grammes. Steel-grey, metallic; crystallizes in rhombohedra. Very brittle. Tarnishes and loses all its lustre. Sp. gr. 5.7 to 5.9. Heated to 180° in close vessels, it volatilizes without fusion. The vapor, slightly oxydized, has a garlic odor. Burns in air with bluish flame. Arsenicum-crust readily soluble in chloride of lime solution, and as powder, burns in Chlorine. NO_2OH readily oxydizes it to arsenic acid $AsO(OH)_3$. *Prep.* from arsenious anhydride by charcoal. $2As_2O_3 + 3C = 3CO_2 + As_4$. **Compounds.** **As** with **H.** **Arsine H_3As** = 78. Or arsenietted hydrogen. Colorless gas of strong garlic odor. Fearfully poisonous. At −30° C., a colorless liquid. Heated to redness in absence of air, into steel-grey crust of As and H. Chlorine deposits a solid brown hydride. Presence of NO_2OH most objectionable in presence of AsH_3, as solid hydride deposited. To be remembered in *Marsh's test.* Solution of SO_4Cu absorbs the gas, whilst Cu_3As_2 is deposited. Passed into NO_2OAg, silver is deposited, and arsenic acid found in solution. $H_3As + 8NO_2(OAg) + 4OH_2 = 8NO_2(OH) + 4Ag_2 + AsO(OH)_3$. *Reinsch's* test consists in deposit of Cu_3As_2 upon a clean strip of copper in ClH solution containing arsenical compound. Burns in air with bluish flame, depositing white vapors of As_2O_3. Incompletely burnt, deposits arsenicum on cold surfaces, instantly dissolved by Cl_2OCa. *Prep.* of H_3As. From zinc arsenide by dilute sulphuric acid. **As** with **Cl.** **Arsenious chloride $AsCl_3$** = 181.5. Heavy, colorless, oily liquid, fuming. By water into ClH and As_2O_3. Arsenicum burns in Cl into $AsCl_3$. Easily made by passing dry Chlorine over heated As_2O_3. [**As** with **Br.** **Arsenious bromide $AsBr_3$.** Deliquescent, colorless prisms. **As** with **I.** **Arsenious iodide AsI_3.** Brick-red solid of sp. gr. 4.39. **As** with **F.** **Arsenious fluoride AsF_3.** Fuming colorless liquid, of sp. gr. 2.73. Boils at 63° C.] **As** and **O.** 1. **Arsenious anhydride As_2O_3** = 198. Also arsenic trioxide, and white

arsenic. Two modifications: vitreous and crystalline. The vitreous of sp. gr. 3.74, most soluble in water. The latter, at 100° only retains 11 per cent., and not more than 3 per cent. when cold. Very soluble in hot ClH. Poisonous: antidotes **magnesia** and precipitated **ferric hydroxide** $Fe_2(OH)_6$. Crystallizes in octahedra; rarely in prisms. Volatile without fusion at 193°.3 C. Its vapor contains one vol. of As and 3 vols. of O condensed into 2 vols. **Arsenites. Arsenious acid** $As(OH)_3$, is tri-basic and feebly acid. *Prep.* of As_2O_3. By roasting arsenical ores: the As oxydizes and sublimes. POTASSIUM ARSENITE $As(OK)_3$, in *Fowler's* solution, used in medicine. ARGENTUM ARSENITE $As(OAg)_3$, is canary-yellow, soluble in H_3N and in NO_2OH. CUPRIC HYDROXYL ARSENITE $As(OH)(O_2Cu)$ or $CuHAsO_3$, is Scheele's Green, soluble in H_3N and in NO_3H. 2. **Arsenic anhydride** $As_2O_5 = 230$. Arsenic pentoxide. White powder, somewhat deliquescent. **Arsenic acid** $AsO(OH)_3$ or H_3AsO_4, is a tribasic acid like orthophosphoric acid. The only well-defined hydrate answers to **Pyr-arsenic acid** $As_2O_3(OH)_4$. By oxydation of As_2O_3 by means of NO_2OH, **arsenic acid** is obtained. Affords an easy method of preparing nitrous acid. $As_2O_3 + 3OH_2 + 2NO_2OH = 2AsO(OH)_3 + 2NOOH$. **Arsenates.** Many isomorphous with phosphates. Isomorphism: similarity in form with analogy of composition. SILVER ARSENATE $AsO(OAg)_3$, liver-brown, soluble in H_3N and in NO_2OH. CUPRIC ARSENATE $AsO(OH)(O_2Cu)$ is blue. **As** and **S**. *a.* **Di-arsenicum disulphide** $As_2S_2 = 214$ "Realgar" Native, in ruby-red prisms. Insoluble in water, and in ClH. Prepared artificially $4As_2O_3 + 7S_2 = 4As_2S_2 + 6SO_2$. White Indian fire is a mixture of 2 parts realgar, 7 of sulphur and 24 of saltpetre. *b.* **Arsenious sulphide** $As_2S_3 = 246$. "Orpiment": aurum pigmentum. Oblique rhombic prisms of yellow color and brilliant lustre. Insoluble in water and in ClH. Very soluble in H_3N, in ammonium carbonate, and sulphide. Also in KOH. Thus: $As_2S_3 + 4KOH = OH_2 + AsOH(OK)_2 + AsSH(SK)_2$. Salts: **Sulpharsenites.** *c.* **Arsenic sulphide** $As_2S_5 = 310$. Yellow substance, by fusion of S_2 with As_2S_3. **Not** precipitated from acid solutions of arsenic acid by SH_2. $2AsO(OH)_3 + 5SH_2 = 5OH_2 + As_2S_3 + S_2$ **Sulpharsenates.** [In sulpharsenites and sulpharsenates Sulphur takes the place of Oxygen in the corresponding salts.] SODIUM SULPHARSENATE $AsS(SNa)_3$.

End of the non-metallic elements.

Remarks.

The reader will have observed that all the **oxides** of non-metallic compounds which are called **anhydrides**, are capable of

forming **acids**. They one and all contain certain **Radicles** or **unsaturated residues** (see p. 2). Nitric acid, for example, may be looked upon as a molecule of water, in which nitric oxide NO has taken the place of an atom of Hydrogen. Now nitrogen is a triad element, and in the radicle NO_2, three out of the four bonds possessed by the dyad element oxygen are united with it: one bond is free or unsaturated, and therefore **NO_2** is a **compound monad radicle**. Nitric acid contains **OH**, or water, minus one atom of hydrogen—the monad radicle which has received the name of **hydroxyl**. All the compound radicles among the non-metallic elements called acids, contain, according to their basicity, one, two, three or four atoms of hydroxyl. The acids are either **monobasic** (like NO.OH; NO_2OH; Cl.OH; ClO.OH; ClO_2OH, &c. &c.): **dibasic** like ($SO_2(OH)_2$); **tribasic**, like $As(OH)_3$ or **tetrabasic** like $AsO(OH)_3$.

There are also radicles, both simple and compound, which form salts of hydrogen. These are distinguished from acids or salts of hydroxl by the prefix hydrogen. Thus we have hydrogen chloride, hydrogen sulphide, hydrogen cyanide. **Cl** is a monad radicle, therefore **ClH** is a saturated compound, a salt of the monad metal hydrogen. **S** is a dyad, and therefore **SH_2** is hydrogen sulphide, the dyad united by its two combining powers with 2 atoms of the monad hydrogen. In hydrogen cyanide **CNH**, carbon having 4 combining powers, is united by 3 to nitrogen, and the monad radicle thus produced, is saturated by its union with **H** in **CNH** or prussic acid.

An acid, whether a compound of hydroxyl or of hydrogen, reflects the union of an electro-negative (radicle) with an electro-positive element or quasi-element. The Hydrogen or the Hydrogen of the hydroxyl may be exchanged for any other Metal, and form so-called **metallic salts**.

The difference in the combining powers of the elements must now be comprehended. But it must also have been noticed that the same element may vary in its quantivalence. Thus nitrogen is a monad in **N_2O**; a triad in **H_3N**, and a pentad in **N_2O_5**. Even in the case of CYANOGEN there is reason to believe that the carbon is sometimes attached by its four combining powers to pentad **N**, leaving one of the bonds of the nitrogen free, instead of, as is generally the case, three of the carbon bonds uniting with the triad **N**, and **C** forming the connecting link of the radicle.

As the basicity of the acids is of great importance, the following Table will be found useful. It will also serve to familiarize the student with common methods of symbolism, and will prevent a slavish adherence to one mode of expression.

1. *a*. Monobasic acids.

Hydrogen chloride	ClH	Hydrogen fluoride	FH
Hydrogen bromide	BrH	Hydrogen cyanide	$(CN)H$
Hydrogen iodide	IH	Hydrogen fluo-borate	$BF_3.FH$

1. *b*. Monobasic acids as salts of (OH) or H.

Nitrous acid	$NO.OH$	$= NO_2H$	$= HNO_2$
Nitric acid	$NO_2.OH$	$= NO_3H$	$= HNO_3$
Hypochlorous acid	$ClOH$	$= ClOH$	$= HClO$
Chlorous acid	$ClO.OH$	$= ClO_2H$	$= HClO_2$
Chloric acid	ClO_2OH	$= ClO_3H$	$= HClO_3$
Perchloric acid	ClO_3OH	$= ClO_4H$	$= HClO_4$
Bromic acid	BrO_2OH	$= BrO_3H$	$= HBrO_3$
Iodic acid	IO_2OH	$= IO_3H$	$= HIO_3$
Periodic acid	IO_3OH	$= IO_4H$	$= HIO_4$
Boracic acid	$BO.OH$	$= BO_2H$	$= HBO_2$
Metaphosphoric acid	PO_2OH	$= PO_3H$	$= HPO_3$
Metantimonic acid	SbO_2OH	$= SbO_3H$	$= HSbO_3$
Hypophosphorous acid	POH_2OH	$= PH_2O_2H$	$= HPH_2O_2$
Hyposulphurous acid	$SOHOH$	$= SHO_2H$	$= HSHO_2$

2. *a*. Dibasic acids.

Hydrogen sulphide	SH_2	Hydrogen titano-fluoride	$TiF_6.H_2$
Hydrogen selenate	SeH_2	Hydrogen silico-fluoride	$SiF_6.H_2$
Hydrogen telluride	TeH_2		

2. *b*. Dibasic acids as salts of OH or H.

Carbonic acid	$CO(OH)_2$	$= CO_3H_2$	$= H_2CO_3$
Metasilicic acid	$SiO(OH)_2$	$= SiO_3H_2$	$= H_2SiO_3$
Metatitanic acid	$TiO(OH)_2$	$= TiO_3H_2$	$= H_2TiO_3$
Metastannic acid	$SnO(OH)_2$	$= SnO_3H_2$	$= H_2SnO_3$
Sulphurous acid	$SO(OH)_2$	$= SO_3H_2$	$= H_2SO_3$
Sulphuric acid	$SO_2(OH)_2$	$= SO_4H_2$	$= H_2SO_4$
Thiosulphuric acid	$SSO(OH)_2$	$= S_2O_3H_2$	$= H_2S_2O_3$
Dithionic acid	$S_2O_4(OH)_2$	$= S_2O_6H_2$	$= H_2S_2O_6$
Trithionic acid	$S_3O_4(OH)_2$	$= S_3O_6H_2$	$= H_2S_3O_6$
Tetrathionic acid	$S_4O_4(OH)_2$	$= S_4O_6H_2$	$= H_2S_4O_6$
Pentathionic acid	$S_5O_4(OH)_2$	$= S_5O_6H_2$	$= H_2S_5O_6$
Selenious acid	$SeO(OH)_2$	$= SeO_3H_2$	$= H_2SeO_3$
Selenic acid	$SeO_2(OH)_2$	$= SeO_4H_2$	$= H_2SeO_4$
Tellurous acid	$TeO(OH)_2$	$= TeO_3H_2$	$= H_2TeO_3$
Telluric acid	$TeO_2(OH)_2$	$= TeO_4H_2$	$= H_2TeO_4$

2. *b*. Dibasic acids as salts of OH or H.—*continued.*

Manganic acid . .	$MnO_2(OH)_2$	$= MnO_4H_2$	$= H_2MnO_4$
Permanganic acid .	$Mn_2O_6(OH)_2$	$= Mn_2O_8H_2$	$= H_2Mn_2O_8$
Chromic acid . .	$CrO_2(OH)_2$	$= CrO_4H_2$	$= H_2CrO_4$
Perchromic acid. .	$Cr_2O_6(OH)_2$	$= Cr_2O_8H_2$	$= H_2CrO_8$
Phosphorous acid .	$POH(OH)_2$	$= PO_3HH_2$	$= H_2PHO_3$
Molybdic acid . .	$MoO_2(OH)_2$	$= MoO_4H_2$	$= H_2MoO_4$
Ferric acid . . .	$FeO_2(OH)_2$	$= FeO_4H_2$	$= H_2FeO_4$

3. Tribasic acids of OH or H.

Orthophosphoric acid .	$PO(OH)_3$	$= PO_4H_3$	$= H_3PO_4$
Arsenious acid . .	$As(OH)_3$	$= AsO_3H_3$	$= H_3AsO_3$
Arsenic acid . . .	$AsO(OH)_3$	$= AsO_4H_3$	$= H_3AsO_4$

4. Tetrabasic acids of OH or H.

Pyrophosphoric acid	$P_2O_3(OH)_4$	$= P_2O_7H_4$	$= H_4P_2O_7$
Pyrantimonic acid .	$Sb_2O_3(OH)_4$	$= Sb_2O_7H_4$	$= H_4Sb_2O_7$
Pyrarsenic acid . .	$As_2O_3(OH)_4$	$= As_2O_7H_4$	$= H_4As_2O_7$
Orthosilicic acid . .	$Si(OH)_4$	$= SiO_4H_4$	$= H_4SiO_4$

B. The Metallic Elements.

As the elements are at least 64 in number, and only 15 have been considered among the non-metallics, the greater number is comprised in this group. Many of the metals are of small importance, and indeed but little known.

All the metals **oxydize.** Some have so great an affinity for O that they can only be preserved under naphtha, or in perfect exclusion from the air. They may be represented as oxides of hydrogenium, in which the latter metal is displaced by an equivalent of another metal. In the **oxides** the whole of the H is displaced; in the **hydroxides** only a portion. E.g K_2O : KOH. The basic oxides may unite directly with the anhydrides to form metallic salts. Thus: $CO_2 + K_2O = CO(OK)_2$ POTASSIUM CARBONATE. With an acid or a salt of hydroxyl, the change to a metallic salt is simultaneous with the production of water. Thus: $K_2O + CO(OH)_2 = OH_2 + CO(OK)_2$. Again, if a hydroxide is brought to a salt of hydroxyl (a so-called acid), water is formed together with a metallic salt. E.g. $HOK + CO(OH)_2 = OH_2 + CO(OH)(OK)$ or $KHCO_3$. Frequently the basylous metal simply displaces H in OH. Thus: $K_2 + SO(OH)_2 = H_2 + SO(OK)_2$ or K_2SO_3. In salts of hydrogen, the behaviour is very similar. Thus: $K_2O + 2ClH = OH_2 + 2ClK$. Again: $KOH + ClH = OH_2 + ClK$. And once more: $K_2 + 2ClH = H_2 + 2ClK$.

In the case of **peroxides**, they can only become basic by a loss of oxygen. This is well seen in the manufacture of Chlorine. There is no manganous salt corresponding with MnO_2; therefore, on addition of hydrogen chloride, one atom of Oxygen forms water with two atoms of H and sets Cl_2 free, the peroxide MnO_2 becoming Manganous oxide MnO, a base which immediately reacts upon further 2ClH to form OH_2, and $MnCl_2$.

Some few metals form **anhydrides** or **acid oxides**, but these are more akin to the non-metals.

Most **oxides** are **insoluble** in water, and so **also** are **most salts**. The oxides of the alkaline metals and their salts are notable exceptions. The chlorides, nitrates and sulphates of the metals are nearly all soluble in water.

The metals themselves are GOOD CONDUCTORS OF HEAT. According to Wiedemann and Franz they rank as follows:—

Silver	1000	Cadmium	577	Sodium	365
Gold	981	Iron (bar)	436	Iron (cast)	359
Copper (rolled)	845	Tin	422	Lead	287
Copper (cast)	811	Steel	397	Antimony	215
Aluminum	665	Platinum	380	Bismuth	61
Zinc, rolled	641				

The metals are also GOOD CONDUCTORS OF ELECTRICITY. As a rule, good conductors of heat are also good conductors of electricity. The conducting power of metals is inversely proportioned to their resistance to the passage of the electric current. According to Matthiessen the electric conductivity of pure metals is as follows:—

Silver	100.00	Calcium	22.14	Palladium	12.64
Copper	77.43	Potassium	20.85	Platinum	10.53
Sodium	37.43	Lithium	19.00	Strontium	6.71
Aluminum	33.76	Iron	14.44	Mercury	1.63
Magnesium	25.47				

With reference to the SPECIFIC HEATS of metals in the solid state, experiment has proved that, if we take the **atomic weights** of the metals instead of **equal weights** for determining the specific heats, the **numbers** expressing the capacity for heat of the atoms are **all equal**. THE METALS ALL POSSESS THE SAME ATOMIC HEAT. This will be at once understood by multiplying the sp. heats of the metals (see Table below) by their respective atomic weights.

	Sp. heat.		Atomic weight.		Atomic heat.
Zinc	0.0950	×	65.2	=	6.390
Lead	0.0310	×	207.	=	6.410
Platinum	0.0324	×	197.5	=	6.399

The slight differences arise from errors of experiment, and we may accept 6.4 as the common atomic heat of the metals. In the determination of the sp. heat, we have a means of ascertaining the atomic weight of a metal. For, if we divide the sp. heat of the metal into 6.4, we obtain the atomic weight.

The elements in the solid state possess the same atomic heats as in their compounds. Hence is the molecular heat the sum of the atomic heats of the combined elements. [N, As, Cl, Br, I, Se and Te, have the same atomic heats as the metals. The atomic heats of P and S are found to be 5.40; of F 5.0; of O 4.0; of Si 4.7; of B 2.75; of H 2.3 and of C 1.76.]

The following Table of the SPECIFIC HEATS of the elements contrasted with water and ice is from Regnault and others:—

Water . .	1.0000	Potassium .	0.1696	Indium .	0.0570
Lithium .	0.9408	Diamond .	0.1469	Cadmium.	0.0567
Ice . . .	0.5050	Manganesium	0.1217	Tin . .	0.0562
Sodium .	0.2934	Iron . . .	0.1138	Iodine .	0.0541
Magnesium	0.2499	Bromine. .	0.1129	Antimony	0.0508
Charcoal .	0.2414	Nickel . .	0.1086	Tellurium	0.0474
Boron . .	0.2352	Cobalt . .	0.1070	Thallium	0.0335
Aluminum	0.2143	Zinc . . .	0.0955	Mercury .	0.0333
Sulphur .	0.2026	Copper . .	0.0952	Gold . .	0.0324
Phosphorus	0.1887	Selenium .	0.0827	Platinum.	0.0324
Silicon . .	0.1774	Arsenicum .	0.0814	Lead . .	0.0310
Phosphorus (red). .	0.1700	Palladium .	0.0593	Bismuth .	0.0308
		Silver . .	0.0570		

METALLIC LUSTRE, a feature of polished metals: wanting when in pulverulent state. OPACITY important: gold-leaf transmits green light. COLOR varies from the whiteness of silver to the yellow of gold, the pale yellow of barium; the red of copper, the bluish-white of lead, &c. Without ODOR. INSOLUBLE in water. HARDNESS varies greatly; from softness of butter, to hardness of steel. [Mohs' scale of hardness in minerals. I. Talc (23 specimens of minerals). II. Gypsum or rocksalt (90). III. Calc-spar cleavable (71). IV. Fluorspar (53). V. Apatite crystallized (43). VI. Felspar cleavable (26). VII. Limpid quartz (26). VIII. Topaz (5). IX. Sapphire or corundum (1). X. Diamond (1).] BRITTLENESS affected by temperature. Bi, Sb and As may be pounded. TENACITY measured by force required to break. If Pb 1, then Cd 1.2 Sn 1.3 Au 5.6 Zn 8 Ag 8.9 Pt 13 Pd 15 Cu 17 Fe 26. MALLEABILITY the power of extension under rollers: Au first. Ag, Cu, Pt, Pd, Fe, Al, Sn, Zn, Pb, Cd, Ni, Co. Gold-leaf $\frac{1}{280000}$ of an inch thick. DUCTILITY involves tenacity, or power of resisting tension. Au, Ag, Pt, Fe

and Cu much alike; then **Pd, Cd, Co, Ni, Al, Zn, Sn, Pb, Tl, Mg, L.** As to FUSIBILITY the metals rank thus:—

Mercury	−38°.8 C.	Lead	325° C.
Gallium	30°.1 ,,	Tellurium	326°.6 ,,
Rubidium	38°.5 ,,	Zinc	412° ,,
Potassium	62°.5 ,,	Antimony	621° ,,
Sodium	97°.6 ,,	Calcium	above red-heat.
Indium	176° ,,	Aluminum	above red-heat.
Lithium	180° ,,	Silver	1023° ,,
Tin	228° ,,	Copper	1091° ,,
Cadmium	228° ,,	Gold	1102° ,,
Bismuth	264° ,,	Cast Iron	1530° ,,
Thallium	294° ,,		

Pure iron, Nickel, Cobalt, Manganesium, Palladium	wind-furnace.	Cerium, Iridium, Osmium, Platinum, Rhodium, Tantalum, Titanium	Fusible in oxy-hydrogen.
Chromium, Molybdenum, Tungsten, Uranium	Imperfect fusion in wind-furnace.		

VOLATILITY very various. **As, Hg, Te, Cd, Zn, K, Na** and **Ru** can be sublimed.

As to SPECIFIC GRAVITY, the metals exhibit great variations.

Lithium	0.593	Cadmium	8.604–8.694
Potassium	0.865	Molybdenum	8.620
Sodium	0.974	Nickel	8.820
Rubidium	1.520	Copper	8.920–8.950
Calcium	1.578	Cobalt	8.950
Magnesium	1.743	Bismuth	9.800
Glucinum	2.100	Silver	10.530
Strontium	2.540	Lead	11.360
Aluminum	2.560–2.67	Ruthenium	11.400
Barium	4.000	Palladium	11.800
Arsenicum	5.700–5.96	Thallium	11.810–11.91
Gallium	5.900	Rhodium	12.100
Tellurium	6.250	Mercury	13.596
Antimony	6.710	Tungsten	17.600
Chromium	6.810	Uranium	18.400
Zinc	7.146	Gold	19.340
Tin	7.292	Iridium	21.150
Indium	7.421	Osmium	21.400
Iron	7.844	Platinum	21.530
Manganesium	8.013		

The metals often occur CRYSTALLIZED; crystals are regular geometrical solids. [In certain positions crystals split regularly; CLEAVAGE. The flat surfaces developed by cleavage called faces or planes. The lines of junction of two planes, its edges; junction of two edges, a plane angle; the point where three or more edges meet, a solid angle. Planes similar, when corresponding angles equal, and edges proportional; edges similar when produced by the meeting of planes respectively similar at equal angles; angles similar when equal, and contained within edges respectively similar. In crystals extra faces often formed by the replacement of an edge or the truncation of an angle. When faces quite equal and similar, called simple forms; those resulting from a combination of two or more simple ones, secondary or compound forms. Great variations in the angles of crystals; instruments of measurement called **Goniometers.** SIX CLASSES OF CRYSTALS. I. The **regular, tessular,** or **cubical system**: three equal axes around which the crystal symmetrically arranged, crossing each other at right angles. In cubes; salt, fluor, iron-pyrites, alum, garnet, diamond, gold, silver, copper, lead, iron, mercury, &c.; in octahedra; alum, magnetite, chrome-iron ore, white arsenic, diamond and many metals: in tetrahedra; copper pyrites, grey copper ore or fahlerz, blende: in rhombic dodecahedra; cobalt-glance, garnet, diamond, fluor, and many metals. Crystals possessing the completest symmetry, called *homohedral* forms: those derived from the former, *hemihedral*.—**II. The right square prismatic, or pyramidal system.** Three axes at right angles to each other, two only equal,—the third axis longer or shorter. Includes the long square prism; tinstone, zircon, apophyllite, idocrase: the short square prism; zircon, &c.: the octahedral square prism: apophyllite, zircon, &c.; and the long square octahedron; anatase, tinstone, zircon, &c. —**III. The rhombic system.** Four axes; three of equal lengths in the same plane, crossing each other at angles of 60°, the fourth, perpendicular to these, may vary in length. The chief forms are: the obtuse rhombohedron; Iceland spar, tourmaline: the acute rhombohedron; Iceland spar: the hexagonal prism; emerald, quartz, tourmaline: the bi-pyramidal dodecahedron; quartz, apatite; and the scaleno dodecahedron; calcite or dog-tooth spar.—**IV. The right rectangular prismatic system.** Three axes, all unequal and all at right angles to each other. Includes the right rectangular prism; heavy spar, prehnite, nitre:—the right rhombic prism: topaz, sulphur, prehnite, heavy spar; the octahedral rhombic prism; topaz, sulphur:—and the rhombic octahedron; harmatome, sulphur, topaz, &c.—**V. The oblique system.** The three axes may all be of unequal length; two cross obliquely, the third is perpendicular to the others. Includes: the oblique rectangular prism; felspar, epidote, mica:—

the oblique rhombic prism; selenite, augite, sphene:—and the oblique rhombic octahedron; felspar, selenite, &c.—**VI. The doubly oblique or anorthic system.** All the axes of unequal length and all cross obliquely. Includes: the doubly oblique prism; axinite, blue vitriol, &c.:—and the doubly oblique octahedron; albite, axinite.]

When a body crystallizes in two irreconcilable forms, it is said to be DIMORPHOUS; when in three, TRIMORPHOUS. Pulverulent bodies, without any regular form, are called AMORPHOUS. Crystallized bodies, with similarity in form and analogy of composition, are called ISOMORPHOUS. E.g. **KCl. KI. KF. K(CN).**

The metals combine together to form **alloys**: they are not so well-defined as those of the metals with O, S, Se, Cl, Br, I, F, &c. The melting-point is often below that of the constituent metals. Alloys of mercury called **amalgams.**

Metals of the alkalies.

	Symbol.		At. weight.	Sp. gr.
Potassium . .	K	=	39.1 . .	0.865
Sodium . .	Na	=	23. . .	0.972
Lithium . .	L	=	7 . .	0.593
Caesium . .	Cs	=	133	
Rubidium . .	Rb	=	85.4 . .	1.520
(Ammonium) .	H_4N	=	18	

I. Group. Metals of the alkalies. They displace one atom of H from the H of the hydroxyl, or the H of the acids: hence **monovalent.** Their basic oxides and hydroxides are very soluble in water, and strongly alkaline to test-paper. Their carbonates are also soluble and alkaline.

I. Potassium or Kalium K = 39.1. K_2 = 78.2.

Discovered by Davy in 1807. Never native. Brilliantly-white metal, volatile at a red-heat, with green vapor. Sp. gr. 0.865. Melts 62°.5 C. Oxydizes so rapidly that it must be kept under naphtha, or hermetically sealed. Decomposes OH_2, the H burning with rose-colored flame in air, and dissolves as **hydroxide KOH.** Absorbs CO, and yields potassium rhodizonate $C_5O_4H_2(OK)_2,OH_2$. *Prep.* 1. By electrolysis of moist KOH: K_2 at the zincode. 2. By strongly heating $CO(OK)_2$ with C_2 = $3CO + K_2$. 3. By heating KOH to whiteness with iron-filings. $4KOH + 3Fe = Fe_3O_4 + 2H_2 + 2K_2$. **Only one basic oxide. Three oxides.** K_2O. K_2O_2. K_2O_4. 1. **Potassoxide** K_2O = 94.2. White, deliquescent caustic. Fuses at red-heat. By

oxydizing K_2 in dry air. Contained as silicate in felspar, mica, &c. With water: **Hydroxide** $HOK = 56.1$. Hard, greyish-white, deliquescent solid. Sp. gr. 2.2. Fuses without change of composition, but volatile at a white-heat. Very soluble in water, and heats greatly; from which in acute rhomboids $HOK, 2OH_2$. Rose-color to flame. Next to caesium and rubidium hydroxides, potassium hydroxide the most powerful base. Precipitates nearly all metallic hydroxides from their solutions. Thus: $Cl_2Ba + 2HOK = 2ClK + Ba(OH)_2$. $NO_2OAg + HOK = NO_2OK + HOAg$. $Cl_6Fe_2 + 6HOK = 6ClK + Fe_2(OH)_6$. *Liquor potassæ* of Pharmacy contains about 6 per cent. of HOK. *Prep.* From dissolved $CO(OK)_2$ in about 10 parts of water, adding calcium hydroxide $(OH)_2Ca$ boiling, decanting, evaporating and fusing in silver or wrought iron. $CO(OK)_2 + (OH)_2Ca = CO(O_2Ca) + 2$**HOK**. HOK is soluble in alcohol; carbonate not, and they are thus separated. [POTASSIUM TETROXIDE K_2O_4. Chrome-yellow powder, formed in heating K_2 in dry air or oxygen. In water gives off O_2, and furnishes solution of the PEROXIDE K_2O_2.] **Sulphides: 5 sulphides.** SK_2. S_2K_2. S_3K_2. S_4K_2. S_5K_2. POTASSIUM SULPHIDE SK_2. Doubtful. Mixed with charcoal, pyrophoric. $SO_2(OK)_2 + 4C = 4CO + SK_2$. POTASSIUM SULPH-HYDRATE HSK, by passing SH_2 into $HOK = OH_2 + HSK$. $2HSK$ into $S_2K_2 + OH_2$ by O of air: then yellow. POTASSIUM TRISULPHIDE S_3K_2, by passing vapor of CS_2 over heated $CO(OK)_2$. Thus: $3CS_2 + 2[CO(OK)_2] = 4CO + CO_2 + 2S_3K_2$. Also contained in liver of sulphur. POTASSIUM TETRASULPHIDE S_4K_2, by reduction of $SO_2(OK)_2$ in CS_2 vapor. PENTASULPHIDE S_5K_2 is sulphate, in which S_4 substitutes O_4. By fusing any sulphide with S. *Hepar sulphuris* is a mixture of higher sulphides with sulphate and thiosulphate of potassium. Again: $6HOK + 6S_2 = 3OH_2 + 2S_5K_2 + S_2O(OK)_2$. SULPHATE $\mathbf{SO_2(OK)_2}$ in hard 6-sided prisms, terminated in 6-sided pyramids. Soluble in 16 of OH_2. Decrepitates when heated. HYDROXYL SULPHATE SO_2OHOK in flattened rhomboidal prisms, soluble in 2 of water. The residuum in the manufacture of NO_2OH from NO_2OK by $SO_2(OH)_2 = NO_2OH + \mathbf{SO_2OHOK}$.—**Potassium carbonate** $CO(OK)_2$; the pearlash of commerce, obtained by incinerating plants, as a white, granular, deliquescent salt; when recrystallized is $\mathbf{CO(OK)_2, 2OH_2}$. HYDROXYL CARBONATE $\mathbf{CO(OH)(OK)}$ in right rhombic prisms, soluble in 4 of water. By solution in hot water into sesqui-carbonate $2[CO(OK)_2], CO(OH)_2$: by heat into carbonate. — ORTHO-SILICATE $Si(OK)_4$. META-SILICATE $SiO(OK)_2$. See **Glass**.—NITRATE $\mathbf{NO_2OK}$, nitre or saltpetre. In 6-sided striated prisms, with dihedral summits. Soluble in $3\frac{1}{2}$ of cold and $\frac{1}{3}$ of boiling water. Cooling, saline taste. Insoluble in alcohol. Fuses at 339° C.: *sal prunelle.* By continued heat into POTASSIUM NITRITE NOOK; finally into O_4K_2 and OK_2,

with evolution of O, N. NO, &c.; **HOK** now prepared from pure nitre by heating to redness one part of NO_2OK, with two parts of copper foil, and solution in water. Gunpowder a mixture of 74.8 parts of nitre, 11.9 of sulphur, and 13.3 parts of charcoal. In detonation: $4NO_2OK + S_2 + 6C = 6CO_2 + 2N_2 + 2SK_2$. In the residue, chiefly $SO_2(OK)_2 + CO(OK)_2$; in fact, like all changes, not so simple as they look. CHLORATE ClO_2OK, rhomboidal scales of pearly lustre, soluble in 16 of cold and 2 of boiling water. Melts at 400° C, and at higher temperature: into PERCHLORATE, chloride and O_2, and the perchlorate into chloride and O_2. Thus: $2ClO_2OK = ClK + ClO_3OK + O_2$. Then $ClO_3OK = ClK + 2O_2$. By SO_4H_2: $2SO_4H_2 + 3ClO_2OK = OH_2 + 2SO_4HK + ClO_3OK + 2ClO_2$. *Prep.* By passing Cl_2 in excess into a thin paste of calcium hydroxide and potassium chloride, and separating the salts by crystallization. $2ClK + Cl_2O_4(O_2Ca) = Cl_2Ca + 2ClO_2OK$. Also: $3Cl_2 + 6HOK = 5ClK + ClO_2OK + 3OH_2$. PERCHLORATE ClO_3OK, in needles, requiring 6 parts of water. CHLORIDE ClK in cubes, volatile at high temperatures. Soluble in 3 parts of water. Twenty-five per cent. of kelp. BROMIDE BrK, also in cubes. Used in medicine and in making Bromine. $2BrK + MnO_2 + 3SO_2(OH)_2 = 2SO_2OHOK + SO_2O_2Mn + 2OH_2 + Br_2$. IODIDE IK cubes, very soluble in water, less in alcohol. Does not brown with ClH (absence of iodate). FLUORIDE FK, in deliquescent cubes. CYANIDE CNK in deliquescent cubes. **Insoluble salts.** POTASSIUM PLATINIC CHLORIDE $2ClK,Cl_4Pt$, a yellow salt, insoluble in mixed alcohol and ether. 100 parts contain 15.98 parts of K, or 19.26 parts calculated as OK_2. SILICO-FLUORIDE $2FK,F_4Si$. Used in making SiF_4.

The **spectrum** of potassium flames is distinguished by the presence of two bright lines; one in the red and another in the violet.

II. Sodium or Natrium Na = 23. $Na_2 = 46$.

A beautiful reddish-tinted metal, crystalline. Sp. gr. 0.972. Fuses at 97°.6 C. Volatile. Burns with yellow flame. Decomposes water. $Na_2 + 2OH_2 = H_2 + 2HONa$. Must be kept in hermetically-sealed tubes, or under naphtha. *Prep.* of Na. $CO(ONa)_2 + 2C = 3CO + Na_2$. **Two oxides**: only one basic. ONa_2 and O_2Na_2; the latter, or PEROXIDE by burning Na_2 in O_2. SODIUM OXIDE $ONa_2 = 62$. Resembles OK_2. By water into HYDROXIDE **HONa**. White, fusible, deliquescent solid. *Prep.* from carbonate: $CO(ONa)_2 + (OH)_2Ca = COO_2Ca + 2HONa$. [**Sodium sulphides.** SNa_2. S_2Na_2. S_3Na_2. S_4Na_2. S_5Na_2.] **Sodium salts soluble in water.** SODIUM CHLORIDE **ClNa**. "Common salt," the commonest salt of sodium. Cubes, soluble in 2½ parts of water at 15°.5 C. Fuses at red-heat, and volatilizes.

Antiseptic. Source of **ClH**. $ClNa + SO_2(OH)_2 = SO_2OH(ONa)$ + **ClH** p. 18. Then, by greater heat: $ClNa + SO_2OH(ONa) = SO_2(ONa)_2 +$ **ClH**. BROMIDE $BrNa$, in sea-water. IODIDE in sea-water and in kelp. In cubes. **Source of iodine** (p. 21). $2INa + MnO_2 + 3SO_2(OH)_2 = 2[(SO_2OH(ONa))] + SO_2O_2Mn + 2OH_2 + I_2$. SULPHATE $SO_4Na_2,10OH_2$. In 4-sided prisms soluble in 2 of water. Effloresces and loses all its water. Aperient: "Glauber's salt." HYDROXYL SULPHATE $SO_2OH(ONa)$. Very acid; non-deliquescent. By heat: *a.* $2SO_2OH(ONa) = OH_2 + SO_2(ONa)_2,SO_3$; then, *b.* $SO_2(ONa)_2,SO_3 = SO_4Na_2 +$ **SO_3**. SULPHITE $SO(ONa)_2,10OH_2$. Oblique, efflorescent prisms, soluble in 4 of water. THIOSULPHATE $SSO(ONa)_2,5OH_2$ is the sodium hyposulphite of commerce. Used in photography. SODIUM CARBONATE **$CO(ONa)_2$**, or 10**OH_2** or $Na_2CO_3,10OH_2$, in oblique rhombic prisms, soluble in 2 of water. Effloresces, fusible. *Prep. a.* Of "*salt cake*": $2ClNa + SO_2(OH)_2 = 2ClH + SO_2(ONa)_2$. *b.* of "*black-ash,*" or "*ball-soda.*" $SO_2(ONa)_2 + 4C = 4CO + SNa_2$. $5SNa_2 + 7[CO(O_2Ca)] = 5SCa,2CaO + 2CO_2 + 5CO(ONa)_2$, and this carbonate loses much of its CO_2 and becomes ONa_2 at the high temperature. The black-ash therefore contains from 20–27 per cent. of sodium oxide: the black-ash dissolved in water, evaporated and crystallized as $CO(ONa)_2,10OH_2$, and the mother-liquor containing $HONa$, evaporated, mixed with saw-dust, roasted in a reverberatory furnace, and residue is the soda-ash of commerce. Re-dissolved and crystallized as **$CO(ONa)_2,10OH_2$**. SESQUI-CARBONATE **$2CO(ONa)_2,CO(OH)_2,2OH_2$** is "Trona salt," or "Natron," found native in rhombic prisms terminated by 4-sided pyramids. SODIUM HYDROXYL CARBONATE **$CO(OH)(ONa)$**, is "bi-carbonate of soda." A white powder, soluble in ten parts of water. Its solution, made in the cold, does not precipitate solution of magnesium sulphate, which distinguishes it from the carbonate of sodium. ORTHO-SILICATE $Si(ONa)_4$. **Glass** is a mixture of various silicates, chiefly sodium and calcium silicates. Soda-glass is more brilliant than potash-glass, but has a greenish tint. See Calcium for glass (p. 46). SODIUM DI-BORATE **ONa_2, $2B_2O_3,10OH_2$** is "Borax." Native in Thibet; in flattened 6-sided prisms with tri-hedral summits. Soluble in 12 of cold, and half their weight of boiling-water. "Tincal" in commerce. By heat intumesces, loses its water and melts into a clear bead. A good flux, and solvent of metallic oxides. Source of BORACIC ACID **$BO(OH),OH_2$**. SODIUM NITRATE **$NO_2(ONa)$**, native in Atacama, Iquique, &c. In obtuse rhomboids, soluble in 2 of water. Somewhat deliquescent. 85 parts NO_2ONa yield as much NO_2OH as 101·1 parts of NO_2OK. **Phosphates.** *a.* **orthophosphates.** ORTHOPHOSPHATE OF SODIUM **$PO(OH)(ONa)_2,12OH_2$**, is the rhombic phosphate, or DI-SODIUM HYDROXYL PHOSPHATE.

Oblique-rhombic prisms of saline taste, soluble in 4 of water. [Solution alkaline, added to neutral silver nitrate, yellow precipitate of silver ortho-phosphate and *free* nitric acid : $PO(OH)(ONa)_2$ + $3NO_2(OAg) = 2NO_2(ONa) + NO_2OH + PO(OAg)_3$.] By adding HONa, we obtain OH_2 and TRI-SODIUM PHOSPHATE $\mathbf{PO(ONa)_3}$, $12\mathbf{OH_2}$ in 6-sided prisms. But, by adding ORTHO-PHOSPHORIC acid $PO(OH)_3$ to di-sodium hydrogen phosphate, we obtain two molecules of: sodium DI-HYDROXYL ORTHO-PHOSPHATE $PO(OH)_2ONa$. SODIUM-AMMONIUM-HYDROXYL-ORTHOPHOSPHATE $\mathbf{PO(ONa)(ONH_4)(OH),4OH_2}$ is "microcosmic salt." Transparent, efflorescent prisms. *Prep.* $ClH_4N + POOH(ONa)_2 = ClNa + PO(ONa)(OH)(OH_4N),4OH_2$. *b.* **pyrophosphates.** SODIUM PYROPHOSPHATE $\mathbf{P_2O_3(ONa)_4,10OH_2}$. In prisms. By heating $POOH(ONa)_2$ to low redness, and crystallizing from water. Thus. $2POOH(ONa)_2 = OH_2 + P_2O_3(ONa)_4$. *c.* **metaphosphates.** SODIUM METAPHOSPHATE PO_2ONa. Transparent glass. By igniting $PO(OH)_2ONa = OH_2 + PO_2(ONa)$. Or, by igniting microcosmic salt. $POONaOH_4NOH = OH_2 + H_3N + PO_2ONa$. SODIUM PLATINIC CHLORIDE $2ClNa,Cl_4Pt$, in striated yellow prisms, very soluble in water. **Insoluble salt.** DI-HYDRIC PYRANTIMONATE OF SODIUM $Sb_2O_3(OH)_2(ONa)_2,6OH_2$.

The **spectrum** of Sodium is distinguished by one fine bright double line of yellow color, identical in position with the dark solar line called D.

[III. Lithium L = 7. L_2 = 14.

A white, lustrous metal, fusible at 180° C. Sp. gr. 0·59. The lightest solid known. From λίθος, a stone. Very oxydizable. Volatile at a red-heat. *Prep.* from fused **ClL** by electrolysis. **One basic oxide.** LITHIUM OXIDE $\mathbf{OL_2}$. Discovered by Arfwedson in 1818. LITHIUM HYDRATE **HOL**, far less soluble than HOK and HONa. Fuses below red-heat, and destroys platinum vessels. Lithium salts in various mineral waters and in the ashes of plants. CHLORIDE $ClL,2OH_2$, most deliquescent. Purple color to flame. Very soluble in mixed alcohol-ether, in which ClK and ClNa insoluble. CARBONATE $CO(OL)_2$, sparingly soluble in water. LITHIUM SULPHATE $SO_2(OL)_2,OH_2$, in flat tables, very soluble. Addition of solution of barium-hydroxide, removes the radicle, and gives lithium hydroxide. LITHIUM ORTHO-PHOSPHATE $PO(OL)_3$, insoluble in alkaline phosphates and in alkaline solutions, but very soluble in dilute acids.

Sources of lithium, besides springs, are: LEPIDOLITE $F(LK),O_3Al_2,2SiO_2$. SPODUMENE or TRIPHANE $3O(LNa)_2,4O_3Al_2,15SiO_2$. PETALITE $3O(LNa)_2,4O_3Al_2,30SiO_2$. Pounded, and ignited with twice their weight of Calcium oxide. The mass is first treated with ClH, then with $SO_2(OH)_2$, and the $SO_2(OL)_2$ separated by

water from the little soluble $SO_2(O_2Ca)$. Solution of barium hydroxide will change $SO_2(OL)_2$ into $2(HOL) + SO_2(O_2Ba)$.

By the spectroscope, traces of Lithium discoverable by a brilliant crimson band, which has a refrangibility between that of the lines B and C of the solar spectrum.]

[IV. Caesium Cs = 133. Cs_2 = 266.

Discovered by Bunsen and Kirchoff in 1860 in a spring at Dürkheim. More electro-positive than potassium. The name from *cæsius*, lavender-blue, in allusion to the two brilliant bands produced by it in the spectrum of a gas-flame. Traces of the chloride in the ash of tobacco, beet-root, coffee and grapes. A rare mineral "Pollux," from Elba, contains 32 per cent. Forms a crystalline amalgam with mercury. Very oxydizable. **Two oxides: one basic.** CAESIUM OXIDE **OCs_2**. CAESIUM HYDROXIDE **HOCs**, very deliquescent and caustic. The most powerful base. **Salts. ClCs** in cubes. **$SO_2(OCs)_2$**, very soluble. **NO_2OCs**, isomorphous with NO_2OK. **$CO(OCs)_2$**, deliquescent. **COOHOCs**, in brilliant prisms. CAESIUM PLATINIC CHLORIDE **$2ClCs,Cl_4Pt$**; the least soluble of the platinic salts.]

[V. Rubidium Rb = 85.4. Rb_2 = 170.8.

Discovered by Bunsen and Kirchoff. More electro-positive than potassium. Brilliant silver-white metal of sp. gr. 1.52. Melts at 38°.5 C. The name from *rubidus*, dark-red, because the spectrum of its salts exhibits a remarkable pair of red lines, less refrangible than Fraunhofer's line A. Most oxydizable. Like caesium it is contained in certain springs; in the ashes of some plants, and in a variety of Lepidolite. **Two oxides: one basic.** RUBIDIUM OXIDE **ORb_2**. HYDRATE **HORb** is deliquescent. **ClRb**, in cubes; very deliquescent. $SO_2(ORb)_2$ in hard, brilliant prisms. Forms alums like sulphates of K_2, Na_2, Cs_2 and $(NH_4)_2$. CARBONATE $CO(ORb)_2$, deliquescent. RUBIDIUM PLATINIC CHLORIDE **$2ClRb,Cl_4Pt$**, only less soluble than the respective Caesium compound.]

Ammonium (H_4N) = 18. (?)

The salts of the hypothetical metal Ammonium are best considered in this place, as they closely resemble those of potassium. Many indeed are isomorphous (similar in form, and analogous in composition). So-called ammonium-amalgam is formed by addition of a solution of ClH_4N to amalgam of sodium. Breaks up spontaneously into H and H_3N.

Ammonium must not be mistaken for nitrogen hydride, or

ammonia H_3N. p. 8. H_3N unites with many metallic salts. Thus with: $ClAg,2H_3N$. $Cl_2Ca,6H_3N$. Cl_2Ca8H_3N. $SO_2(O_2Cu),4H_3N,OH_2$. $NO_2(OAg),3H_3N$. When H_3N and dry CO_2 are brought together, we obtain AMMONIUM CARBAMATE $CONH_2(OH_4N)$. CARBAMIC ACID $CONH_2(OH)$, has not been isolated. One atom of amidogen H_2N displaces 1 atom of OH. So-called CARBAMIDE $CO(NH_2)_2$ would be formed by substituting NH_2 for OH, and this happens when ammonia and carbon-oxychloride $COCl_2$ are brought together. AMMONIUM SULPHAMATE $\mathbf{SO_2NH_2OH_4N}$, results, when SO_3 and $2H_3N$ are brought together. With acids, it is different: we have salts of ammonium. AMMONIUM HYDROGEN SULPHIDE $\mathbf{SH(H_4N)}$ is the common test for the metals, precipitating in neutral solutions, black sulphides of ferrous, cobalt and nickel, white zinc sulphide and aluminum hydroxide, flesh-colored manganous sulphide, and greenish chromium hydroxide. *Prep.* by saturating H_3N with SH_2. Absorbs O and becomes yellow disulphide $S_2(H_4N)_2$. Thus: $8SH(H_4N) + 5O_2 = 4OH_2 + 2[S_2(H_4N)_2] + 2[S_2O(OH_4N)_2]$. Dissolves as sulphur salts the electronegative sulphides; with evolution of SH_2. AMMONIUM CHLORIDE $\mathbf{ClH_4N} = 53.5 = 4$ vols. Or H_3NClH. Semi-transparent, tough, fibrous. In cubes, octahedra or fern-shaped. Soluble in less than 3 parts of water. IODIDE $I(H_4N)$. NITRATE $NO_2O(H_4N)$, source of N_2O at 250° C. and of $2OH_2$. Striated prisms. NITRITE $NO(OH_4N)$; by heat into $2OH_2$ and N_2. SULPHATE $SO_2(OH_4N)_2$, in prisms, soluble in two of cold water. CARBONATE $CO(OH_4N)_2$. SESQUICARBONATE OF AMMONIUM $2[CO(OH_4N)_2],CO_2$. "Smelling-salts." By loss of AMMONIUM CARBAMATE $COH_2N(OH_4N)$, into AMMONIUM HYDROGEN CARBONATE $CO(OH)(OH_4N)$ (two molecules). *Prep.* by subliming ammonium chloride with calcium carbonate: $6ClH_4N + 3CO(O_2Ca) = 3Cl_2Ca + OH_2 + 2H_3N +$ sesquicarbonate. **Ammonium sodium hydroxyl phosphate** $PO(OH)(OH_4N)(ONa),4OH_2$ is microcosmic salt. **Insoluble salt.** AMMONIUM PLATINIC CHLORIDE $2ClH_4N,Cl_4Pt$, yellow powder; contains 7.62 per cent. of H_3N.

Metals of the alkaline earths.

	Symbol.		At. weight.	Sp. gr.
Barium . .	. Ba	=	137 . .	. 4.000
Strontium	. Sr	=	87.5 . .	. 2 540
Calcium .	. Ca	=	40 . .	. 1.578

Dyad metals which decompose water at ordinary temperatures. Their oxides are strongly basic, alkaline, soluble as hydroxides. Carbonates insoluble in water; bi-carbonates are soluble. Most of their salts are insoluble in water. In solution, they can be separated from the alkalies by boiling with ammonium carbonate.

VI. Barium Ba = 137.

Dyad metal of silver-white color. It is malleable, melts below red-heat, and oxydizes readily. Name from *βαρύς*, heavy. From fused Cl_2Ba by electrolysis. **Two oxides. BaO** and **BaO_2**. One basic: BARIUM OXIDE **BaO**. Grey and fusible. BARIUM HYDROXIDE **$(OH)_2Ba$**, crystallizes with $8OH_2$; soluble in 20 of cold and 2 of boiling water. Solution strongly alkaline: test for CO_2. Also used for making certain hydroxides from their sulphates. Thus: $SO_2(OK)_2 + (OH)_2Ba = SO_2O_2Ba + 2HOK$. Very poisonous: antidotes, Sodium or Magnesium sulphate. *Prep. a.* by heating $(NO_2)_2O_2Ba$ to redness. *b.* by boiling solution of barium sulphide with Cupric oxide. $6SBa + 5OH_2 + 8CuO = 4SCu_2 + S_2O(O_2Ba) + 5(OH)_2Ba$. BARIUM DIOXIDE or PEROXIDE BaO_2. Grey. HYDRATE **$BaO_2,6OH_2$**. Used for making O_2H_2, p. 7. Also a source of Oxygen. *Prep.* BaO heated in a stream of dry air = BaO_2. Also by fusing ClO_2OK with BaO. $ClO_2OK + 3BaO = ClK + 3BaO_2$. Dissolve in water and $BaO_2,6OH_2$ separates. SULPHIDE OF BARIUM **BaS**. By strongly heating SO_4Ba with charcoal $= 4CO +$ **BaS**. HYDRATED SULPHIDE $BaS,6OH_2$, in colorless crystals. When dissolved in water: $2BaS + 2OH_2 = (OH)_2Ba + BaS,SH_2$. Barium sulphide used for making soluble Barium salts. **Soluble salts.** BARIUM CHLORIDE **$Cl_2Ba,2OH_2$**, in flat 4-sided tables, soluble in $2\frac{1}{2}$ parts of water. Yellowish-green color to flame. Test for soluble carbonates, phosphates, sulphates, &c., as these salts are insoluble in water, but soluble in ClH except SO_4Ba. Insoluble in alcohol. BARIUM NITRATE $(NO_2)_2(O_2Ba)$. Octahedral. Soluble in 8 parts of cold and 3 of boiling water. Less soluble in ClH and in NO_2OH. Green-fire is a mixture of 45 parts of dry nitrate, with 15 of S, 10 of ClO_2OK, $2\frac{1}{2}$ of lamp-black and $1\frac{1}{2}$ of S_3Sb_2. Requires great care in mixing. BARIUM CHLORATE $(ClO_2)_2O_2Ba$. Beautiful green color to flame. ACETATE, $3OH_2$, in flattened prisms. BARIUM THIOSULPHATE **$S_2O(O_2Ba),OH_2$**, in small, brilliant crystals. **Insoluble salts.** BARIUM SULPHATE **SO_4Ba**. Native as "heavy spar" in right rhombic prisms and massive. Sp. gr. 4.59. Source of Barium salts by ignition with charcoal: into sulphide. Used for adulterating white lead. Insoluble in ClH or NO_2OH. CARBONATE OF BARIUM **$CO(O_2Ba)$**. Native as "Witherite" in 6-sided prisms, terminated by 6-sided pyramids. White powder, soluble as Cl_2Ba or $(NO_2)_2O_2Ba$ in the respective acids: CO_2 evolved. BARIUM SILICOFLUORIDE **F_2Ba,F_4Si**. CHROMATE **CrO_4Ba**, yellowish powder. Barium is weighed as **SO_4Ba**, containing 65.66 per cent. of **BaO**.

The **spectrum** of barium contains a number of characteristic green lines, by which it is easily detected.

VII. Strontium Sr = 87.5.

A dyad metal of yellow color. Sp. gr. 2.54. Harder than lead. Decomposes cold water. The name from Strontian in Argyleshire, where Hope discovered "Strontianite," the carbonate of strontium. *Prep.* from fused CHLORIDE, Cl_2Sr. **Two oxides, SrO and SrO_2.** Only one basic; STRONTIUM OXIDE SrO. White. From $(NO_2)_2(O_2Sr)$ at a red-heat. With water, HYDROXIDE $Sr(OH)_2$. Its HYDRATE $Sr(OH)_2$,8aq. requires 50 parts of cold and 24 of boiling water for solution. Strongly alkaline: a test for CO_2. [STRONTIUM PEROXIDE SrO_2. By O_2 over heated Strontium oxide.] SULPHIDE **SSr**. From $SO_4Sr + 4C = 4CO +$ **SSr**. **Salts of strontium: soluble in water.** CHLORIDE **$Cl_2Sr,6OH_2$**. Deliquescent needles, very soluble in alcohol and thus separable from Cl_2Ba. Burns with crimson flame. NITRATE **$(NO_2)_2O_2Sr$, $5OH_2$**, octahedra soluble in 5 of water. ("Red-fire" a mixture of 80 parts of dry nitrate, 22 parts of S, 20 parts of ClO_2OK and 5 parts of lamp-black. Great care required in mixing: no pounding in mortar.) CHROMATE **CrO_4Sr**. SILICO-FLUORIDE **F_2Sr,F_4Si**. **Insoluble salts.** SULPHATE OF STRONTIUM **SO_4Sr**, native as "Celestine" in right-rhombic prisms of bluish hue. Often accompanies **S** in Sicily. CARBONATE **COO_2Sr**, native as Strontianite. PHOSPHATE **$POOHO_2Sr$**, white powder. Strontium estimated as **SO_4Sr**, containing 56.52 per cent. of SrO. The spectrum is most characteristic.

VIII. Calcium Ca = 40.

A dyad metal, never native. Light-yellow color. Sp. 1.578. As hard as gold, malleable and ductile. Tarnishes slowly in dry air. Decomposes OH_2 immediately. Burns magnificently when heated in O into CaO: in Cl_2 into Cl_2Ca. Prepared from fused mixture of 2**Cl_2Ca** with **Cl_2Sr**, by electrolysis. Also from I_2Ca by $Na_2 = 2NaI +$ **Ca**. **Two oxides**: CaO and CaO_2. **One basic oxide: Calcium oxide CaO** = 56. The well-known "Quicklime." White, caustic, infusible. In oxy-hydrogen an intense light: *lime-light*. With water it combines, heats and slakes: into CALCIUM HYDROXIDE **$(OH)_2Ca$** or "slaked lime," soluble in 700 parts of cold and 1280 parts of boiling water. Alkaline. Absorbs CO_2: a test. Absorbs SH_2 as OH_2 and SCa. Excess of $(OH)_2Ca$ in lime-water, called "milk of lime." Calcium hydroxide in mortars, cements, &c. *Prep.* by heating CALCIUM CARBONATE **$CO(O_2Ca)$** to redness: $CO(O_2Ca) = CO_2 + CaO$. [CALCIUM PEROXIDE **$CaO_2,8OH_2$** is precipitated by adding lime-water to SODIUM PEROXIDE Na_2O_2.] CALCIUM SULPHIDE **SCa**. White, insoluble in water. Phosphorescent. *Prep.* $SO_4Ca + 4C =$

$4CO + \mathbf{SCa}$. Chief constituent of soda-waste. When moist, absorbs O, and supplies CALCIUM THIOSULPHATE, $S_2O(O_2Ca)$. Thus: $2SCa + OH_2 + 2O_2 = Ca(OH)_2 + \mathbf{S_2O(O_2Ca)}$. [CALCIUM PENTA-SULPHIDE $\mathbf{S_5Ca}$. By boiling S_2 with $(OH)_2Ca$, we obtain thiosulphate as well. Thus: $3[(OH)_2Ca] + 6S_2 = 3OH_2 + S_2O(O_2Ca) + 2\mathbf{S_5Ca}$. CALCIUM PHOSPHIDE P_2Ca_2? By distilling P_2 with CaO. $7P_2 + 14CaO = 2[P_2O_3O_4Ca_2] + 5\mathbf{P_2Ca_2}$.—CALCIUM SILICIDE $SiCa_2$ in lead-grey scales. By ClH into SILICONE or CHRYSEON $\mathbf{Si_6O_4H_6}$.] **Salts of calcium: soluble in water.** CHLORIDE $\mathbf{Cl_2Ca,6OH_2}$, in striated, deliquescent prisms. Saturated solution boils at 179°.5 C. By heat at 150° C. into $Cl_2Ca,2OH_2$; porous, used for desiccating gases. Found in sea-water. Artificially: $COO_2Ca + 2ClH = OH_2 + \mathbf{CO_2} + Cl_2Ca$. Absorbs H_3N. [BROMIDE $\mathbf{Br_2Ca}$. IODIDE I_2Ca.] OXY-CHLORIDE $\mathbf{Cl_2OCa}$, see p. 19. "Chloride of lime." Evolves Cl_2 in air. Made from calcium hydroxide by absorption of Cl_2. According to Kolb, $Cl_4O_6H_6Ca_3$ by solution in water into: $2OH_2 + Cl_2Ca + (OH)_2Ca + (OCl)_2Ca$.—CALCIUM CHLORATE $(ClO_2)_2O_2Ca$, deliquescent. NITRATE $(NO_2)_2O_2Ca$ in deliquescent prisms. CALCIUM BI-CARBONATE $\mathbf{CO(O_2Ca).CO(OH)_2}$, in Calcareous waters. Deposited as COO_2Ca in so-called "stalactites" and "stalagmites." "Temporarily hard" waters contain it: softened by boiling or addition of Calcium hydroxide;—Clark's process. SULPHATE $\mathbf{SO_2O_2Ca,2OH_2}$. Transparent, flattened prisms as "Selenite." Rectangular prisms as "Anhydrite" $SO_2(O_2Ca)$. Massive, found as alabaster. Soluble in 400. Heated below 260° C., loses its water and forms "gypsum" or "Plaster of Paris." Contained in all spring-waters. CALCIUM TETRA-HYDROXYL ORTHO-PHOSPHATE $\mathbf{P_2O_2(OH)_4(O_2Ca)}$ is so-called "superphosphate" when yet mixed with $SO_2(O_2Ca)$ in manure. Used in making P_2. **Insoluble calcium salts. Calcium carbonate** $CO(O_2Ca) = CaCO_3 = 100$. As marble, limestone, oolite, chalk, &c. In coral, shells, &c. Dimorphous, rhombohedral in "Iceland spar" and in 6-sided right rhombic prisms in "Aragonite." $Cl_2Ca + CO(ONa)_2 = 2ClNa + COO_2Ca$. **Calcium fluoride** F_2Ca. In cubes, octahedra and massive in "fluorspar." Used for ornaments, and for making **FH** and $\mathbf{2FH,SiF_4}$ (pp. 23, 25). **Calcium orthophosphate** $P_2O_2(O_2Ca)_3$ in bone-earth. Native as **Apatite** $F_2Ca,3[P_2O_2(O_2Ca)_3.]$ Is precipitated by phosphates from soluble calcium salts with $2OH_2$. [SODIUM-CALCIUM BORATE $[2(5BO,ONa,O_2Ca.)3B_2O_3,18OH_2]$, native at Iquique, Peru.]

Calcium is precipitated quantitatively as **oxalate** $C_2O_2O_2Ca$, and weighed as **carbonate** $CO(O_2Ca)$, which contains 56 per cent. of CaO.

The **spectrum** of Ca is peculiar, containing a number of distinct bright lines.

The Magnesian Group.

	Symbols.	At. weight.	Sp. Gr.	Melting-point.
Magnesium .	Mg	= 24 . .	1.743 .	
Zinc . . .	Zn	= 65.2 . .	7.146 .	412° C.
Cadmium . .	Cd	= 112 . .	8.604 .	228° C.
Glucinum . .	Be	= 9.3 . .	2.100 .	900° C. (?)

The metals belong to the dyad group and are volatile and combustible. Only one oxide. Their carbonates are soluble in ammonium carbonate.

IX. Magnesium Mg = 24.

A dyad metal, never native. Silver-white, malleable and ductile. Sp. gr. 1.743. Very slowly oxydizes in damp air, to magnesia. Nearly as volatile as zinc. Burns brilliantly when heated in O, in Cl, Br, I, S vapor, &c. Its combustion in air, a substitute for sunlight in photography. Unites directly with N. Dissolves in HCl evolving H_2. Precipitates Zn, Fe, Co and Ni from solutions of their salts. With As and Sb salts, acidulated, Mg gives rise to H_3As and H_3Sb. *Prep.* of **Mg**. From $Cl_2Mg + Na_2 = 2ClNa +$ **Mg**. Also from fused chloride by electrolysis. **One oxide: basic.** MAGNESIUM OXIDE **MgO** = 40. White, infusible, alkaline. As HYDROXIDE **$(OH)_2Mg$** requiring 5142 parts of water at 0° C. for solution, and over 36,000 parts at 100° C. Is precipitated as such, from all its soluble salts by any of the preceding hydroxides. Thus: $(OH)_2Ca + Cl_2Mg = Cl_2Ca + (OH)_2Mg$. *Prep.* by heating *magnesia alba*: then called *magnesia usta*. **Sulphide SMg** sparingly soluble. By S_2C in vapor over red-hot MgO + C. **Nitride N_2Mg_3** is crystalline. **Salts of magnesium: soluble in water.** CHLORIDE **Cl_2Mg**, white, deliquescent. Used in making **Mg**. In prisms as **$Cl_2Mg,6OH_2$**. OXY-CHLORIDE **$MgCl_2,MgO$**, sets with water like plaster of Paris. BROMIDE Br_2Mg, in sea-water. MAGNESIUM SULPHATE **$SO_2(O_2Mg),7OH_2$**, "Epsom salt." Right rhombic prisms soluble in 3 of cold and $1\frac{1}{2}$ of boiling water. Nauseous taste. In sea and other waters. Springs at Epsom. *Prep.* from mother-liquor of sea by calcium hydroxide and the hydroxide of magnesium by $SO_2(OH)_2$ into sulphate. Or, from dolomite by $SO_2(OH)_2$, and separation of resulting sulphates by water. NITRATE **$(NO_2)_2O_2Mg,6OH_2$**, deliquescent prisms. **Insoluble salts. Magnesium carbonate COO_2Mg** = 84. Native as "magnesite," white, hard, amorphous. The most abundant magnesian mineral is "Dolomite," a **carbonate of calcium** and **magnesium $CO(O_2Ca)$, $CO(O_2Mg)$**, valuable as building-stone (Houses of Parliament). From a solution in **CO_2** as **$CO(O_2Mg)$**, 3**OH_2**. Magnesia alba of Pharmacy is a basic carbonate, a varying mixture of the carbonate with $(OH)_2Mg$. **Magnesium**

hydroxyl ortho-phosphate $PO(OH)(O_2Mg), 7OH_2$, in minute needles. **Ammonium magnesium orthophosphate** $\mathbf{PO(OH_4N)(O_2Mg)6OH_2}$, known as "triple phosphate." Quite insoluble in H_3N. By heat into: **Magnesium pyrophosphate** $P_2O_3(O_2Mg)_2$, (H_3N and OH_2) containing 36.21 per cent. of **MgO**. Magnesium estimated as such. [**Silicates** are very important minerals. MnO and FeO often substitute, in part, or entirely, MgO and CaO. **Chrysolite** $Si(O_2Mg)_2$. **Meerschaum** $2[SiOO_2Mg], SiO_2, 4OH_2$. **Talc** $4[SiOO_2Mg], SiO_2, 4OH_2$. **Steatite or soapstone** $3[SiOO_2Mg], SiO_2$. **Serpentine** $\mathbf{2[SiOO_2Mg](OH)_2Mg,OH_2}$. **Augite** is magnesium and calcium silicate, in which Fe and Mn interchange. **Hornblende** is also a silicate of Mg, Ca, Al and Fe, with FK and F_2Ca. **Asbestos** is a variety of hornblende.

X. Zinc Zn = 65.2.

A dyad metal, never native. Bluish-white, hard and lustrous. Sp. gr. 7.146. Melts at 412° C.; boils at 1040° C. It is brittle, but between 100° C. and 150° C., it is malleable and ductile. Oxydizes very slowly, hence used for coating sheet-iron. Readily attacked by Cl, Br and I. Dissolved by the acids. $Zn + SO_2(OH)_2, 2OH_2 = SO_2O_2Zn + 2OH_2 + H_2$. $Zn + 2ClH = Cl_2Zn + H_2$. $3Zn + 8NO_2OH = 3[(NO_2)_2O_2Zn] + 4OH_2 + 2NO$. Also by POTASSIUM HYDROXIDE: $Zn + 2HOK = H_2 + OK_2, OZn$. Zinc, the electropositive element in most batteries; the wire attached to it is the zincode or negative pole. Precipitates most metals, but is precipitated by all the preceding. Burns with luminous greenish light into its one oxide, ZnO. **One basic oxide: Zinc oxide** ZnO = 81.2. White amorphous powder, insoluble in water. Canary-yellow whilst red-hot. "Tutty" is impure ZnO. Isomorphous with MgO. **Zinc hydroxide** $\mathbf{(OH)_2Zn}$, is white, gelatinous, insoluble in water, soluble in H_3N and in HOK. ZINC SULPHIDE SZn. Native as **Blende**, the common ore of zinc: in rhombic dodecahedra. Its HYDROSULPHIDE $\mathbf{OH_2,SZn}$ is white and insoluble in HOK. Not precipitated in acid solutions of zinc-salts by SH_2, but in neutral by SHH_4N. **Metallurgy**: when roasted, SZn, into **ZnO** + SO_2: then ZnO is reduced by charcoal $2ZnO + C = CO_2 + 2Zn$. **Salts soluble in water.** CHLORIDE Cl_2Zn. White, deliquescent, fusible at 100° C. An escharotic. Also forms "Burnett's disinfecting liquid." SULPHATE $\mathbf{SO_2O_2Zn, 7OH_2}$, in colorless 4-sided prisms; efflorescent. "White vitriol." Soluble in 2½ parts of cold water. Used in medicine and by calico-printers. **Insoluble salts. Zinc carbonate** $\mathbf{COO_2Zn}$, native as **Calamine** the best ore of zinc. White, when pure. **Metallurgy.** By roasting = **ZnO** + $\mathbf{CO_2}$. Then the oxide reduced by charcoal, and distilled. Precipitated as a **basic carbonate** $\mathbf{3COO_2Zn, 5[(OH)_2Zn],OH_2}$. **Silicate** $Si(O_4Zn_2),OH_2$ is also a mineral

called electric calamine. Zinc is best weighed as **ZnO**; 100 parts contain 80.24 of **Zinc**.

XI. Cadmium Cd = 112.

A dyad metal, never native. Tin-white, malleable and ductile. Melts at 228° C; boils at 860° C. Sp. gr. 8.6. More volatile than zinc, the ores of which it accompanies. Tarnishes but little in air. Burns when strongly heated in air, depositing brownish fumes of the oxide. Readily dissolved by ClH, by $SO_2(OH)_2,2OH_2$ and by NO_2OH. **Only one oxide: basic.** CADMIUM OXIDE **CdO** = 128. Brown. HYDROXIDE $\mathbf{(OH)_2Cd}$ is white, insoluble in HOK, soluble in H_3N. CADMIUM SULPHIDE SCd, yellow. Native as "Greenockite," in 6-sided prisms. Its HYDRATE $\mathbf{(OH)_2SCd}$, yellow, is precipitated by SH_2 from solutions of cadmium salts, and may thus be separated from zinc-salts. The **metal Cd,** obtained by roasting SCd, and reducing the CdO with charcoal. In Zinc-ores containing **Cadmium,** the latter, being more volatile, may be received apart as long as brown fumes are deposited. **Soluble salts.** CHLORIDE $\mathbf{Cl_2Cd,2OH_2}$, 4-sided prisms. IODIDE I_2Cd, in pearly scales. NITRATE $\mathbf{(NO_2)_2O_2Cd}$. SULPHATE $\mathbf{SO_2O_2Cd,4OH_2}$ very soluble. **Insoluble salts. Carbonate of cadmium,** $\mathbf{COO_2Cd}$, white, and insoluble in ammonium carbonate: thus separated from zinc as carbonate. Estimated as **oxide** CdO, which contains 87.5 per cent. of metal.

[XII. Glucinum or Beryllium Be = 9.3.

A dyad metal, never native. White, lustrous, malleable and ductile. Sp. gr. 2.1. Fusible at 900° C.? Does not decompose water. ClH and $SO_2(OH)_2,2OH_2$, dissolve it as chloride and sulphate: H_2 evolved. NO_2OH only a feeble action. *Prep.* from $Cl_2Be + Na_2 = 2ClNa +$ **Be. Only one oxide: basic. Beryllium oxide BeO** = 25.3. White, insoluble in water. **Hydroxide**$(OH)_2Be$, gelatinous, white, and soluble in ammonium carbonate, and so, easily separated from aluminum hydroxide. Absorbs CO_2 from the air, and displaces H_3N from its salts. **Glucinum aluminate** $\mathbf{Al_2O_3,BeO}$ occurs native in the gem "*chryso-beryl.*" **Soluble salts.** Sweet: hence γλυκύς sweet. GLUCINUM CHLORIDE $\mathbf{Cl_2Be}$, sublimes in white needles. Crystallizes $Cl_2Be,4OH_2$. SULPHATE $\mathbf{SO_2O_2Be,4OH_2}$, in octahedra. **No alum.** $\mathbf{SO_2(OK)_2}$, $\mathbf{SO_2O_2Be,2aq}$. **Insoluble salts. Ortho-silicate** $Si(O_4Be_2)$, native as *Phenakite*. The "emerald" or "beryl" (sometimes so clear as to have been used in *Brillen*, spectacles) is double **silicate of aluminum** and **beryllium** $\mathbf{3BeO,Al_2O_3,6SiO_2}$. After removal of the SiO_2, as F_4Si, by treatment with F_2Ca and SO_4H_2, the resulting sulphates can be easily, in part, separated by ammonium

sulphate which forms an "alum" with the aluminum. Au reste, beryl-hydroxide is soluble in ammonium carbonate. Estimated as beryllium oxide **BeO.**]

Metals of the earths.

	Symbol.		At. weight.
Aluminum . .	Al	=	27.50
Yttrium . . .	Y	=	92.00
Erbium . . .	E	=	168.90
Lanthanum . .	La	=	139.00
Didymium . .	D	=	144.75
Cerium . . .	Ce	=	138.00

These are triads, or pseudo-triads. Their oxides are of an earthy character, and have the most powerful affinity for oxygen. They are precipitated as hydroxides by ammonium sulphide.

XIII. Aluminum Al = 27.5.

Tetrad in **aluminum ethide** $(C_2H_5)_4Al$; as pseudo-triad in **chloride** $(Cl_3Al)_2$. Never native. Discovered by Woehler in 1827. White metal with bluish tint, malleable, ductile. Sp. gr. 2.6. Fuses at about 450° C. Burns with bluish-white light in oxygen. Inalterable in air: used for weights. Not attacked by NO_2OH; easily by ClH. $6ClH + Al_2 = 3H_2 + \mathbf{Cl_6Al_2}$. Dissolved by potassium hydroxide. **Alloys.** Aluminum bronze Cu_9Al. *Prep.* of **Al.** *a.* by electrolysis of fused $2ClNa,Cl_6\mathbf{Al_2}$. *b.* $2ClNa, Cl_6Al_2 + 3Na_2 = 8ClNa + 2\mathbf{Al}$. *c.* from Cryolite with sodium: $6FNa,F_6Al_2 + 3Na_2 = 12FNa + \mathbf{Al_2}$. **Only one oxide: basic. Aluminum oxide** $O_3Al_2 = \mathbf{Al_2O_3} = 103$. Native as "corundum" in 6-sided prisms; emery is pounded corundum. "Sapphire" and "ruby" are tinted Al_2O_3. Pure aluminum oxide is white, and fusible in oxy-hydrogen. After strong ignition, insoluble in acids. United with various bases to **aluminates.** Chryso-beryl $Al_2O_3.BeO$. Spinelle ruby is Al_2O_3,MgO. Gahnite Al_2O_3,ZnO. Sodium aluminate $(ONa_2)_3Al_2O_3$ is made from Bauxite, a hydrated aluminum ferric-oxide. **Aluminum hydroxide** $(OH)_6Al_2$, yellowish, translucent mass. "Diaspore" is a natural hydroxide $\mathbf{(OH)_2O_2Al_2}$ or OH_2,Al_2O_3. Soluble in HOK; insoluble in H_3N. The basis of "clay." **Sulphide** $\mathbf{S_3Al_2}$: by burning Al in the vapor of sulphur. **Salts soluble in water.** ALUMINUM CHLORIDE $Cl_6Al_2 = 268$. Crystalline, translucent; sublimes at a dull red-heat. Deliquescent. $\mathbf{Cl_6Al_2,12OH_2}$ in 6-sided prisms. $Al_2O_3 + 3C + 3Cl_2 = 3CO + \mathbf{Cl_6Al_2}$. ALUMINUM SULPHATE $\mathbf{(SO_2)_3(O_2)_3Al_2,18OH_2}$ in thin scales, soluble in two parts of water. Prepared by decomposing clay with

$SO_2(OH)_2$. POTASSIUM ALUM $(SO_4)_4K_2Al_224OH_2$, in octahedra and in cubes, soluble in 18 of cold and 2 of boiling water. Loses 10 of OH_2 at 100° C., and other $10OH_2$ at 120°, and the rest at 200° C.: *alumen ustum*. AMMONIUM ALUM containing $(NH_4)_2$ in place of K_2, is prepared from the H_3N of gas-works, mixed with acid aluminum sulphate. All true monad metals may substitute K_2. Thus Na_2, Cs_2, Rb_2, L_2, Tl_2, Ag_2. **Isomorphous salts,** *e.g.* [$(SO_4)_4Na_2Al_2,24OH_2$.] [$(SO_4)_4(NH_4)_2,Al_2,24OH_2$.] [$(SO_4)_4L_2Al_2,24OH_2$.]

Insoluble salts. Aluminum fluoride F_6Al_2. As "Cryolite," in Greenland. $3FNa, F_6Al_2$. Contains 13 per cent. of aluminum. **Ortho-phosphate** $PO(O_3Al)$. The "turquoise" is a hydrated phosphate $P_2O_5,2Al_2O_3,5OH_2$. **Clay** is a **hydrated aluminum silicate** $2SiO_2,Al_2O_3,2OH_2$. **Felspars.** "Orthoclase" or "adularia" is potassium felspar. $SiO_4AlK,2SiO_2$ or $6SiO_2,Al_2O_3,K_2O$. "Albite" is sodium felspar, and "Labradorite" calcium felspar. "Pumice" is altered felspar. "Obsidian" is fused pumice. "Granite" is a mixture of quartz, felspar and mica—the latter consisting of magnesium and aluminum silicate. "Syenite" contains Hornblende instead of mica. "Garnets" are basic double silicates of calcium and aluminum. **Glass** is a mixture of various insoluble silicates with excess of silica. **Bohemian glass** is $SiO,(OK)_2,SiO(O_2Ca),4SiO_2$. [$K_2O,3SiO_2,CaO,3SiO_2$.] **Crown-glass** $SiO(OK)_2,SiO(O_2Ca),2SiO_2$. **Flint glass.** $SiO(OK)_2$, $SiO(O_2Pb)4SiO_2$. In this glass, lead replaces calcium. **Bottle-glass** contains aluminum and iron silicates, besides calcium and potassium silicates. It contains more basyl than the other varieties. [See Miller's 'Inorganic Chemistry,' revised by McLeod, p. 420.]

[XIV. Yttrium Y = 92.

Is a triad metal, never native. Burns brilliantly in O_2. The name, from Ytterby in Sweden, where "Gadolinite," a silicate of yttrium, glucinum, cerium and iron, is met with. *Prep.* from the chloride, by sodium. **One basic oxide: Yttria** Y_2O_3, nearly white powder, of sp. gr. 4.842. Salts colorless. **Sulphate** $(SO_4)_3Y_2$, $8OH_2$. Colorless solution which does not exhibit an absorption spectrum.]

[XV. Erbium E = 168.9.

The metal probably a triad. Not isolated. **One basic oxide. Erbium oxide** E_2O_3. Faint rose-red color. Infusible, but glows with intense green light, exhibiting in spectroscope a continuous spectrum intersected by a number of bright bands. **Sulphate** $(SO_4)_3E_2$, $8OH_2$, in rose-colored crystals.]

[XVI. **Lanthanum La = 139.**

Discovered by Mosander in 1841 "hidden," λανθάνω I lie hid, in Cerium. A triad metal never native. Only **one basic oxide.** La_2O_3, buff-colored. **Hydroxide** $(OH)_3La$. **Chloride** $LaCl_3$. **Sulphate** $(SO_4)_3La_2$. Salts colorless, precipitated by soluble oxalates. No absorption spectrum.]

[XVII. **Didymium D = 144.75.**

A triad metal, so named because of its close association (from δίδυμος twin) with Lanthanum. Discovered by Mosander. **One basic oxide: Didymium** oxide D_2O_3. White. **Peroxide** DO_2, brown. Salts rose-colored. **Sulphate** $(SO_4)_3D_2,8OH_2$, isomorphous with erbium and yttrium sulphates. Salts exhibit a well-marked absorption-spectrum, containing two black lines inclosing a very bright space.]

[XVIII. **Cerium Ce = 138.**

A triad metal never native. Discovered by Klaproth in 1803. The metal little known. Forms two **basic oxides. Cerous oxide** Ce_2O_3 and **Ceric oxide** CeO_2. CEROUS OXIDE Ce_2O_3, greyish-blue powder, easily changed into CeO_2 by air. Salts colorless. Oxalate used in medicine. CERIC OXIDE CeO_2 is formed when Ce_2O_3 or $(OH)_3Ce$ are ignited in an open crucible. Yellowish-white; orange-red whilst red-hot. HYDROXIDE $3(OH_2),2CeO_2$ is of bright-yellow color. Salts yellow, and brown-red. No ceric chloride, as CeO_2 behaves like MnO_2 towards ClH, yielding $CeCl_3$.]

Metals more or less allied to iron.

	Symbol.		At. weight.	Sp. gr.
Ferrum	Fe	=	56	7.84
Manganesium	Mn	=	55	8.01
Chromium	Cr	=	52.2	7.81
Cobalt	Co	=	58.8	8.95
Nickel	Ni	=	58.8	8.28
Uranium	U	=	120	18.40

This group includes the magnetic metals, as well as the diamagnetic Uranium. They decompose water at a red-heat. SH_2 in acid solutions, does not precipitate salts of these basyls.

XIX. Ferrum Fe = 56.

Very rarely native, except in meteorites, and in mica-slate at Canaan in Connecticut. Almost silver-white: of sp. gr. 7.844.

The most tenacious of metals, also the most magnetic. Unchanged in dry air, and in pure water free from O and CO_2. Rusts in damp air. Burns when heated in O into magnetic oxide. Dilute sulphuric acid and hydrogen chloride dissolve it freely. Thus: $SO_4H_2,2OH_2 + Fe = \mathbf{SO_4Fe} + 2OH_2 + H_2$. $2ClH + Fe = \mathbf{Cl_2Fe} + H_2$. Strong nitric acid renders it passive; dilute, dissolves Fe as $(NO_2)_2O_2Fe$. Fe decomposes steam at a red-heat: $Fe_3 + 4OH_2 = 4H_2 + Fe_3O_4$. "Meteorites" contain in addition to iron, nickel and cobalt, together with traces of copper, manganesium, chromium, tin, magnesium, carbon, sulphur and phosphorus. Bar-iron contains from 0.2 to 0.4 per cent. of carbon. When strongly heated it softens, and can be "welded" by hammering. *Prep.* by strongly heating filings of bar-iron mixed with $\frac{1}{5}$ of pure Ferric oxide: thus are all traces of C and Si oxydized at the expense of the oxide, and a fusible slag formed. Melts at 1530° C. Iron is dyad, as well as pseudo-triad, or hexad, in its chief combinations. **Ores of iron. Ferroso-ferric oxide** or "magnetite" Fe_3O_4, both massive and in octahedra. Gives, by reduction with charcoal, the purest iron. "Specular iron-ore" $\mathbf{Fe_2O_3}$, in rhomboids from Elba and Formosa. "Red hæmatite" $3(\mathbf{OH_2}),2\mathbf{Fe_2O_3}$, both fibrous and compact: soluble in ClH as Cl_6Fe_2. When roasted, it loses its water and is easily reduced by coal or charcoal. "Spathic iron-ore" $\mathbf{CO(O_2Fe)}$, in yellowish, lenticular crystals, as well as massive. By roasting it oxydizes, and loses CO_2; resulting Fe_2O_3 is reduced by fuel. "Clay iron-stone" is an impure ferrous carbonate, mixed with clay, limestone, &c.: it is the chief iron-ore of Great Britain, and is reduced in the blast-furnace. Ore roasted: thus Fe_2O_3 obtained. Lime CaO is admixed, in order to prevent the SiO_2 of the ore from uniting with FeO; the SiO_2 forms a fusible CALCIUM ORTHOSILICATE SiO_4Ca_2 or "slag," and coal is added to reduce the ferric oxide. The "cast-iron" or "pig-iron" contains both carbide and silicide. Three kinds of cast-iron; grey, mottled and white. In **white cast-iron**, all the **carbon is combined.** "Spiegeleisen" contains about 5.08 per cent. of carbon, answering to CFe_4. It is the most fusible. The **mottled cast-iron** is coarse-grained and contains visible points of uncombined carbon or graphite. The **grey cast-iron** contains **more uncombined carbon** than the mottled: it is soft and more fusible than the mottled: when heated, and suddenly cooled, used for making chilled shot. **Cast-iron, into wrought.** "Refining:" carbon burnt out and Si got rid of as FERROUS SILICATE $Si(O_2Fe)_2$. "Puddling" removes yet more C and Si. By SIEMENS' process, malleable iron direct from the ore, previously mixed with lime and 25 per cent. of small coal, heated in a horizontal rotatory furnace by means of a regenerative gas furnace. **Alloys.** "Red short iron" is tough at ordinary temperatures, but brittle at

red-heat. Contains S, As and Cu. "Cold short iron" is brittle at common temperatures: made from finery cinder $Si(O_2Fe)_2$ and always contains Phosphide of iron. Steel contains from 0.7 to 1.7 per cent. of carbon. In the cementation process, iron unites with 1.5 per cent. of carbon. In "Bessemer" steel, wrought-iron is worked up with a sufficient quantity of "spiegel-eisen" to give at once the necessary amount of carbon. By means of a blast of air under pressure of 12 to 25 lbs. per square inch, the melted pig-iron has its carbon burnt into CO, and when thus de-carbonized, it is mixed with the right proportion of spiegel-eisen. **Oxides. Two basic oxides, besides an intermediate one.** 1. **Ferrous oxide FeO.** 2. **Ferric oxide Fe_2O_3.** 1. FERROUS OXIDE **FeO** = 72. Very unstable *per se*. Its HYDROXIDE **$(OH)_2Fe$** is white, unstable, passing by oxydation through light-green, bluish-green, black and red-brown, to ferric hydrate. 2. FERRIC OXIDE $Fe_2O_3 = 160$. Red-brown. Red hæmatite and specular iron-ore are varieties. "Rouge" is ferric oxide. Its hydroxide $3(OH)_2 2Fe_2O_3$ is red-brown and bulky. Precipitated, and dried at 100° C., $(OH_2),Fe_2O_3$. 3. FERROUS-FERRIC OXIDE **FeO,Fe_2O_3** is black; hydroxide also. Forms no specific salts. **S and Fe.** FERROUS SULPHIDE SFe = 88. Reddish-brown. Either by direct union of the elements or by heating FeS_2 with Fe. FeS is used in making SH_2. Thus: $2ClH + SFe = SH_2 + Cl_2Fe$. Ferrous salts are precipitated as black hydrated sulphide by $S(H_4N)H$. Thus: $Cl_2Fe + OH_2 + S(H_4N)H = SFe,OH_2 + ClH + ClH_4N$. FERRIC DISULPHIDE $FeS_2 = 120$. "Iron-pyrites" or "Mundic," in cubes of brassy lustre or massive. Sp. gr. 4.98. Also as "marcasite" in right rhomboidal prisms. When roasted in air, gives SO_2 and Fe_2O_3: chief source of SO_2 in making sulphuric acid (p. 15). Heated in absence of air, yields **Sulphur**: $3S_2Fe = S_4Fe_3 + S_2$. "Arsenical pyrites" or mispickel SAsFe. MAGNETIC SULPHIDE S_8Fe_7, is soluble in HCl (S_2Fe not).—PHOSPHIDE **PFe_2** hard and brittle: in "cold short iron." 1. **Soluble ferrous salts.** FERROUS CHLORIDE Cl_2Fe white and volatile. In crystals **$Cl_2Fe,4OH_2$**, green and very soluble. FERROUS IODIDE **$I_2Fe,4OH_2$** in green crystals. $I_2 + Fe = I_2Fe$. NITRATE **$(NO_2)_2O_2Fe,6OH_2$** in pale-green rhomboids; very unstable. FERROUS SULPHATE **$SO_4Fe,7OH_2$**. In rhomboids of sea-green color, soluble in 2 of water. "Green vitriol." Its solution absorbs O and deposits BASIC FERRIC SULPHATE $SO_3,2Fe_2O_3,3OH_2$. Thus: $20SO_4Fe + 5O_2 + 6OH_2 = 6(3SO_4Fe_2) + 2$ of basic salt. Becomes red-brown on exposure: hence copperas or "Couperose." It loses water, and by further heat: $2SO_4Fe = Fe_2O_3 + SO_2 + SO_3$. See p. 14, Nordhausen Sulphuric acid. A good reducing agent. See Gold. FERROUS BI-CARBONATE **$CO(O_2Fe),CO_2$**, in chalybeate waters: absorbs O and deposits Ferric hydrate. 2. **Insoluble ferrous**

salts: **Ferrous carbonate** $CO(O_2Fe) = 116$. White. "Spathic iron-ore." Precipitated as greenish hydrated carbonate by soluble carbonates. **Ferrous hydrogen ortho-phosphate** $PO(OH)(O_2Fe)$, white: becomes blue. **Ferrous ortho-silicate** $Si(O_2Fe)_2$, is "finery slag." **Ferric salts. Soluble.** FERRIC CHLORIDE $Cl_6Fe_2 = 325$, in brown scales. $Cl_6Fe_2,6OH_2$ in red, deliquescent crystals. Reduced by SH_2. $Cl_6Fe_2 + ClH + SH_2 = 2(Cl_2Fe) + 3ClH + S$. FERRIC IODIDE I_6Fe_2. FERRIC SULPHATE $(SO_4)_3Fe_2$, yellowish-white, deliquescent. "Coquimbite" with $9OH_2$, silky-white mineral. **Alums**, in which Fe_2O_3 takes the place of Al_2O_3 in the common alums. Isomorphous. Thus: $(SO_4)_4K_2Fe_2, 24OH_2$. FERRIC NITRATE $(NO_3)_6Fe_2,12OH_2$. **Insoluble ferric salts. Basic ferric sulphate** already mentioned. **Ferric phosphate** $POO_3Fe, 2OH_2$, is white, and insoluble in acetic acid. "Vivianite" $PO(OH)(O_2Fe),2PO(O_3Fe),8OH_2$.

Ferric acid $FeO_2(OH)_2$ is scarcely separable, so immediately does it evolve O, and deposit ferric hydrate. **Potassium ferrate** $FeO_2(OK)_2$ is very soluble in water, to amethystine solution. Thus: $(OH)_6Fe_2 + 3Cl_2 + 10KOH = 6ClK + 2FeO_4K_2 + 8OH_2$. Iron is estimated as FERRIC OXIDE Fe_2O_3, containing 70 per cent. of the metal. A ferrous, easily changed into a ferric salt by NO_2OH. Thus: $6SO_4Fe + 2NO_2OH + 3SO_4H_2 = 2NO + 4OH_2 + 3(SO_4)_3Fe_2$.

XX. Manganesium Mn = 55.

Discovered by Gahn in 1774. Never native. Dyad and tetrad; also a pseudo-triad in manganic oxide Mn_2O_3. Greyish-white, brittle metal. Sp. gr. 8.01. Oxydizes speedily in air; decomposes water slowly, and must be preserved under naphtha. Its alloy with iron, harder and more elastic than iron. *Prep.* by heating manganous carbonate to whiteness, with charcoal, in a smith's forge. **Oxides.** Two basic, two indifferent and two acids. 1. **Manganous oxide** $MnO = 71$. A powerful base. Olive-green. Absorbs O when ignited and changes into brown Mn_3O_4. By heating COO_2Mn in a stream of H to keep off the air $= CO_2 + MnO$. **Hydroxide** $(OH_2)MnO$ is white, soluble in H_3N, especially in presence of salts of H_4N. **Salts.** Pink or rose-red. MnO is isomorphous with MgO, ZnO, FeO. 2. **Manganic oxide** $Mn_2O_3 = 158$. In acute, square-based octahedra as "Braunite." Also as "manganite" OH_2,Mn_2O_3, in brilliant, right-rhombic prisms. Very feeble base. Isomorphous with Fe_2O_3 and Al_2O_3. Substitutes these bases in "alums." Gives a violet color to glass, and a red color to the amethyst. 3. **Manganous-manganic oxide** $Mn_3O_4 = MnO,Mn_2O_3$, native in "Hausmannite." Obtained by igniting MnO, $CO(O_2Mn)$ or Mn_3O_4. Not basic. 4. **Manganese dioxide or peroxide** MnO_2

$= 87$. The chief ore; "pyrolusite," in steel-grey, rhombic prisms. "Varvicite" $Mn_2O_3,2MnO_2,OH_2$. "Wad" is a hydrate. Much used in the arts. Not basic. Ignited, gives **O**. $3MnO_2 = Mn_3O_4 + O_2$. Also when heated with sulphuric acid: $2MnO_2 + 2SO_4H_2 = 2\mathbf{SO_2(O_2Mn)} + 2OH_2 + \mathbf{O_2}$. With hydrogen chloride gives **Cl**. $4ClH + MnO_2 = 2OH_2 + \mathbf{MnCl_2} + Cl_2$. Decomposed in presence of SO_4H_2 by oxalic acid $C_2O_2(OH)_2 = 2CO_2 + 2OH_2 + SO_2O_2Mn$. Gives its own weight of CO_2 nearly. 5. **Manganic acid** $MnO_2(OH)_2$. Green, unstable. Isomorphous with $SO_2(OH)_2$, $FeO_2(OH)_2$, and $CrO_2(OH)_2$. **Manganates.** $\mathbf{MnO_4K_2}$ is "mineral chamælion." Condy's disinfectant is principally $\mathbf{MnO_4Na_2}$. Decomposed by water into permanganate, sodium hydroxide and manganese dioxide. A little free acid, thus: $4SO_4H_2 + 5MnO_4K_2 = 4OH_2 + 3SO_4K_2 + 2Mn_2O_8K_2 + SO_4Mn$. By sulphurous acid: $2SO(OH)_2 + MnO_4K_2 = SO_4K_2 + SO_4Mn + 2OH_2$. 6. **Permanganic anhydride,** Mn_2O_7. Deep-green unstable liquid. **Permanganic acid** $Mn_2O_6(OH)_2$, a brown crystalline mass best known in its salts. Violet and amethystine. POTASSIUM PERMANGANATE $Mn_2O_6(OK)_2 = 316.2$. In needles. *Prep.* $3MnO_2(OK)_2 + 2CO_2 = MnO_2 + 2CO(OK)_2 + \mathbf{Mn_2O_6(OK)_2}$. Or: $2MnO_4K_2 + Cl_2 = 2KCl + \mathbf{Mn_2O_6(OK)_2}$. **Sulphides. Manganous sulphide** SMn, native as "manganese blende." As **hydrated sulphide** SMn,OH_2, when a manganous salt is precipitated by ammonium sulphide; flesh-color but oxydizing and browning on exposure. **Manganous salts. Soluble in water.** CHLORIDE $\mathbf{Cl_2Mn,4OH_2}$, in tablets of pink hue, very deliquescent. May be purified from Cl_6Fe_2 in the residues of Cl_2 manufacture, by boiling with $CO(O_2Mn)$ or with SMn,OH_2; Mn takes the place of Fe in solution. MANGANOUS SULPHATE $\mathbf{SO_4Mn,7OH_2}$ in prisms at 5° C. Otherwise with $\mathbf{5OH_2}$. **Insoluble salts. Manganous carbonate** $\mathbf{CO(O_2Mn)}$, native as "manganese spar" of pink hue, isomorphous with $CO(O_2Ca)$, $CO(O_2Fe)$, &c. Precipitated as: $\mathbf{2[CO(O_2Mn)],OH_2}$. **Phosphate** $\mathbf{PO(OH)O_2Mn}$, white powder. **Borate** $B_2O_2(O_2Mn)$, white. **Manganic salts.** MANGANIC CHLORIDE Cl_6Mn_2; dark-brown. By heat into $2Cl_2Mn + Cl_2$. MANGANIC SULPHATE $(SO_4)_3Mn_2$, with SO_4K_2, forms MANGANIC ALUM $(SO_4)_4MnK_2,24OH_2$.

XXI. Cobaltum Co = 58.8.

Never native. Dyad in its chief oxide. Trivalent in its cobaltic salts which are very unstable. Discovered by Brandt in 1733. Reddish-white, brittle metal fusible in wind-furnace. Sp. gr. 8.95. Very tenacious. Magnetic. Slowly dissolved by ClH and dilute $SO_4H_2,2OH_2$. Readily by NO_2OH. *Prep.* from oxalate by white heat. **Arsenide** $\mathbf{As_2Co}$, is "tin-white cobalt" or "speiss-cobalt," the best ore. **Arsenio-sulphide**

SCoAs, is "Cobalt glance," in cubes, dodecahedra, and octahedra. **Oxides: two basic**, and **one intermediate**. 1. **Cobaltous oxide** $CoO = 74.8$. Greenish-grey. Strong base. By roasting, it absorbs O and becomes Co_3O_4. Used as a pigment. **Hydroxide** $\mathbf{CoO,OH_2}$, is rose-colored, readily soluble in ammonium carbonate. Salts blue or pink. "Zaffre" is an impure oxide. "Smalt" is a glass colored blue by cobaltous silicate. The ore is roasted, so as to oxydize the cobalt, but to leave the associated Nickel, Iron and Copper combined with arsenicum and sulphur, as arsenides and sulphides: it is then slowly fused with potassium carbonate and silica. A glass of potassium and cobalt silicate results, called "Smalt." The so-called "speiss" at the bottom of the crucible consists mainly of sulphides and arsenides of Ni, Fe and Cu. 2. **Cobaltic oxide** $\mathbf{Co_2O_3}$ is black. Its **hydroxide** $\mathbf{(OH)_6Co_2}$ also black. *Prep.* by passing Cl_2 through cobaltous hydroxide suspended in solution of potassium hydroxide. $3[CoO(OH_2)] + Cl_2 = Cl_2Co + (OH)_6Co_2$. By gentle heat into $\mathbf{Co_3O_4}$. Very feeble base. **Cobaltous sulphide SCo** is black. **Hydrate** OH_2CoS also black, and precipitated thus from solutions of cobaltous salts by $SH(H_4N)$. **Cobaltous salts; soluble.** CHLORIDE $\mathbf{Cl_2Co,6OH_2}$ in ruby-red octahedra. NITRATE $\mathbf{(NO)_2O_2Co, 6OH_2}$, deliquescent, red mass. **Insoluble salts. Cobaltous carbonate** $3[CO(O_2Co)],2OH_2$. Always precipitated as basic carbonate. **Cobaltous arsenate** $\mathbf{As_2O_5(OCo)_3,8OH_2}$ is "cobalt bloom." Cobalt imparts a deep blue tint to borax fused on a loop of platinum wire.

Co is estimated in the metallic form, and as $\mathbf{Co_3O_4}$, corresponding to 73.34 per cent. of cobalt.

XXII. Nickel Ni = 58.8.

Never native. Dyad. Discovered by Cronstedt in 1751. Analogous to, and almost always associated with, Cobalt. Hard, lustrous, white, tenacious metal. Sp. gr. 8.8. Fused in wind-furnace. Magnetic, but loses its property at 350° C. Not easily attacked by acids, except by NO_2OH. *Prep.* from NICKEL OXALATE $C_2O_2(O_2Ni)$ in a wind-furnace $= 2CO_2 +$ **Ni**. Nickel is now deposited by electrolysis upon articles of iron, steel, copper, brass, &c. The **alloy** of German silver $Cu_5Zn_3Ni_2$ important. Chief **ores** of **nickel** are: **Nickel arsenide** $\mathbf{As_2Ni_2}$ or "Kupfer-nickel." **Nickel di-arsenide** $\mathbf{As_2Ni}$: by heat in close vessels into **As** and As_2Ni_2. **Nickel arsenio-sulphide AsNiS** or nickel-glance. "Speiss," obtained as a fused product in making "smalt" (see Cobalt) is mainly, fused Kupfer-nickel as far as Nickel is concerned. The separation, roughly, of the Co from the Ni, in the chlorides, is accomplished by Cl_2OCa, which converts CoO into Co_2O_3 and precipitates it, and then of the **Ni** as $\mathbf{(OH)_2Ni}$

by $(OH)_2Ca$. The reduction of the oxide by carbon is sufficiently simple. The separation is also effected by converting Co into potassium cobalti-cyanide and precipitating NICKEL CYANIDE $(CN)_2Ni$ by ClH. **One basic oxide. Nickel oxide** $NiO = 74.8$. Olive-green. By igniting the carbonate out of contact of air. **Hydroxide $(OH)_2Ni$**, bulky light-green. Forms insoluble compounds with HOK, HONa, $(HO)_2Ba$, $(HO)_2Sr$. H_3N dissolves it to a blue solution. Salts are green. **Nickel peroxide** Ni_2O_3 is black. **Hydrate $(OH)_6Ni_2$.** Not basic. Thus: $2(OH)_2Ni + Cl_2 + 2HOK = 2KCl + (OH)_6Ni_2$. — **Nickel sulphide** $SNi = 90.8$, native as "Millerite." As black **hydrated sulphide** $(OH_2)SNi$, from solutions of nickel salts by SHH_4N. **Subsulphide SNi_2. Disulphide S_2Ni. Soluble salts of nickel.** CHLORIDE $Cl_2Ni,9OH_2$ is green. SULPHATE $SO_4Ni,7OH_2$, green rhombic prisms, isomorphous with $SO_4Mg,7OH_2$, $SO_4Zn,7OH_2$, $SO_4Mn,7OH_2$, and $SO_4Fe,7OH_2$. Soluble in 3 parts of water. NITRATE $(NO_2)_2O_2Ni$. **Insoluble salts. Carbonate of nickel** $3[CO(O_2Ni)],2OH_2$. Basic carbonate always precipitated. **Nickel cyanide C_2N_2Ni**, apple-green.

The nickel salts impart a reddish-yellow color to the borax bead.

Nickel is estimated as **NiO**, containing 78.67 per cent. of Ni.

XXIII. Chromium Cr = 52.2.

A pseudo-triad metal in its chromic salts. Never native. Discovered by Vauquelin in 1797. Steel-grey. More intractable than Platinum. Sp. gr. 6.81. Insoluble, even in aqua regia. *Prep.* By strong ignition of Cr_2O_3 with Charcoal, in a wind-furnace. Or, by passing the vapor of sodium over red-hot chromium chloride: $Cl_6Cr_2 + 3Na_2 = 6ClNa + Cr_2$. **Two basic oxides, and one intermediate.** 1. **Chromous oxide** CrO, only known as **hydroxide $(OH)_2Cr$**. Brown, which absorbs O and becomes hydrate of **Chromous-chromic oxide $CrO,Cr_2O_3,aq.$** Powerful base: forms chromous salts of pale-blue color, which absorb O. 2. **Chromic oxide**, $Cr_2O_3 = 152.4$. Green, isomorphous with Al_2O_3, Mn_2O_3, Fe_2O_3 and substitutes Al_2O_3 in alums. Coloring-matter of the emerald, chlorite, pyrope, serpentine, &c. Employed as a green color for porcelain and glass. As hydroxide $(OH)_6Cr_2,4aq.$ of light-blue color. Salts green and uncrystallizable; violet and crystallizable. *Prep.* By heating AMMONIUM CHROMATE $CrO_4(NH_4)_2$. Or, crystalline, by heating potassium dichromate. "Chrome iron-ore" or **Ferrous-chromic oxide** FeO,Cr_2O_3, is the chief ore of chromium, corresponding to magnetic oxide of iron, Cr_2O_3 displacing Fe_2O_3. In octahedra and massive. 3. **Chromic anhydride** CrO_3, in brilliant, dark-crimson, deliquescent prisms.

Fuses at 200° C., and looks black. By further heat into $2(CrO_3, Cr_2O_3) + 3O_2$, and then into Cr_2O_3 and $3O_2$. From $F_6Cr + 3OH_2 = 6FH + CrO_3$. **Chromic acid** $CrO_2(OH)_2$ in solution. **Chromates.**—Alkaline chromates soluble in water. POTASSIUM DICHROMATE $CrO_2(OK)_2,CrO_3$ in 4-sided tables of red colour. POTASSIUM CHROMATE $CrO_2(OK)_2$ in yellow prisms, isomorphous with $SO_2(OK)_2$. LEAD CHROMATE $CrO_2(O_2Pb)$ forms "chrome-yellow." DIBASIC LEAD CHROMATE $CrO_2(O_2Pb),PbO$ is almost scarlet. SILVER CHROMATE $CrO_2(OAg)_2$ is dark-red. **So that the name, Chromium,** from Χρῶμα, color, is well-deserved. When chrome-iron-ore is calcined with mixed $CO(OK)_2$ and NO_2OK, the product when treated with water gives up potassium chromate, the starting-point of all the preparations. 4. **Perchromic acid** Cr_2O_7,OH_2 or $Cr_2O_6(OH)_2$. Blue and unstable. Formed by addition of O_2H_2 to solution of $CrO_2(OH)_2$. **Chromic sulphide** S_3Cr_2, black, shiny scales. By S_2C over ignited Cr_2O_3. Chromic hydrate is precipitated by ammonium sulphide from solutions of chromic salts, soluble with green color in HOK. **Chromium nitride** Cr_3N_4, chocolate-brown. By heating Cl_6Cr_2 in dry H_3N. **Salts of chromic.** CHROMIC CHLORIDE Cl_6Cr_2, pale-violet scales. Volatile. *Prep.* $2Cr_2O_3 + 6C + 6Cl_2 = 6CO + 2Cl_6Cr_2$. [**Chloro-chromic acid** CrO_2Cl_2, a dark-red, fuming liquid, of sp. gr. 1.92. Boils at 116°.8 C. By distilling ClNa with $CrO_2(OK)_2,CrO_3$ and $SO_2(OH)_2$. It is chromic anhydride in which Cl_2 substitutes O. Decomposed by $2OH_2$ into $CrO_2(OH)_2 + 2ClH$. As neither Br nor I forms a similar compound, it is also a test for a chloride.] **Chromic fluoride** F_6Cr_2. Blood-red liquid. **Chromic sulphates.** Insoluble, red: $(SO_4)_3Cr_2$. Soluble, green, uncrystallizable $(SO_4)_3Cr_2,5OH_2$. Soluble, violet, crystallizable $(SO_4)_3Cr_2,15OH_2$. POTASSIUM-CHROME-ALUM $(SO_4)_4K_2Cr_2,24OH_2$. Amethystine. CHROMIC NITRATE $(NO_3)_6Cr_2$. Green. Chromium oxide imparts deep-green color to fused borax. It is estimated as Cr_2O_3 which contains 68.63 per cent. of **Chromium.**

[XXIV. Uranium U = 120.

Never native. Discovered by Klaproth in "Pitchblende," which consists mainly of uranous-uranic oxide, UO,U_2O_3. It is steel-grey, slightly malleable, and not oxydized at ordinary temperatures; but burns beautifully when strongly heated. Sp. gr. 18.4. Diamagnetic. Analogous in its chemical relations with Fe and Mn. *Prep.* by heating uranous chloride with potassium: $Cl_2U + K_2 = 2ClK + U$. **Two basic and two intermediate oxides.** 1. **Uranous oxide** $UO = 136$. Forms green salts with a tendency to oxydize. **Uranous chloride,** Cl_2U, green, deliquescent octahedra: volatile. *Prep.* by

heating the oxide with charcoal in a stream of Chlorine. 2. **Di-uranous-uranic oxide** $2UO,U_2O_3$, by igniting uranic nitrate, or heating UO to redness in air. Black: used in painting china. 3. **Uranous-uranic oxide** UO,U_2O_3, by heating the di-uranous-uranic oxide moderately in a current of air. No salts. Chief constituent of Pitchblende. Sp. gr. 7.31. 4. **Uranic oxide** U_2O_3, as a brick-red powder, by heating $U_2O_3,2OH_2$ to 300° C. Behaves like a base and a radicle. Salts of yellow color. Imparts yellow color to glass. $\mathbf{2NO_3,U_2O_2,6OH_2}$ in long, striated prisms of yellow color is the **nitrate**, perfectly soluble in ether. UO, or **uranyl** behaves like a metal. On addition of an alkali, **uranate** of the metal $\mathbf{2U_2O_3,OK_2,3OH_2}$ is precipitated of yellow color. **Uranyl chloride**, $Cl_2U_2O_2$, by passing Cl_2 over uranous oxide. **Sulphides.** SH_2 gives no precipitates. But ammonium sulphide gives a black precipitate with uranous, and a yellowish-brown with uranic salts. "Uranite" is **Calcium di-uranyl phosphate** $2\,PO_4,2U_2O_2,Ca,8OH_2$. "Chalcolite," is $2PO_4,2U_2O_2Cu,8OH_2$.]

Metals more or less allied to Tin.

	Symbol.		At. weight.
Stannum.	. **Sn**	=	**118.0**
Titanium	. **Ti**	=	**50.0**
Zirconium	. **Zr**	=	**89.5**
Thorinum	. **Th**	=	**231.5**

XXV. Stannum or Tin Sn = 118.

Tetrad metal, not found native. Very white and lustrous; malleable, but little ductile. Sp. gr. 7.292. Emits a peculiar crackling sound when bent. Melts at 228° C. Tarnishes slowly and quite superficially. Crystalline tin in "moirée métallique." When strongly heated in air, burns into **Stannic oxide** SnO_2, its only ore. ClH dissolves it slowly as **Stannous chloride**; boiled with sulphuric acid, into **Stannic sulphate**, and tin is changed into **Metastannic acid** by NO_2OH. **Alloys.** *Britannia metal*, of equal parts of Sn, Brass, Sb and Bi. *Pewter*, of 4 parts of Sn, and 1 part of lead. *Fine solder*, 2 parts of Sn to 1 of Pb. *Common solder* of equal parts of Sn and Pb. *Coarse solder* of 2 of Pb to 1 of Sn. **Amalgams.**—see **Hg**, p. 74. **Two oxides.** 1. **Stannous oxide** SnO = 134. Black, crystalline needles. By boiling **Hydroxide** $\mathbf{OH_2,2SnO}$ with HOK insufficient to re-dissolve it. Powerful base. Rapidly absorbs O, and becomes SnO_2. Hydroxide is white, and very soluble in HOK and HONa. 2. **Stannic oxide** SnO_2 = 150. White. Native as "tin-stone." As alluvial deposit, known as "stream

tin;" as constituent of granite and slate rocks, as "mine tin." In Cornwall, Saxony, Bohemia, New Zealand and Malacca. **Metallurgy.** From Tin-stone SnO_2 by charcoal or anthracite. Mine-tin contains SAsFe as well as S_2FeCu and much SiO_2. By careful roasting, much of the As is volatilized as As_2O_3, and S as SO_2. Lime CaO, is added to form a slag with SiO_2. Further submitted to liquation process, pure tin melts first, and may be removed: the impure or "block tin" contains certain alloys in small quantities. **Stannic acid** $SnO(OH)_2$ or H_2SnO_3, white, gelatinous precipitate, obtained by adding H_3N to solution of Cl_4Sn, or a quantity of chalk insufficient for its entire decomposition. **Stannates.** $SnO(OK)_2,3OH_2$, $SnO(ONa)_2,3OH_2$. So then stannic hydroxide behaves also like an acid. It is insoluble in H_3N. Heated to 140° C. into **meta-stannic acid** $5SnO_2,H_2O,4OH_2$ or $H_2Sn_5O_{11},4aq.$, which is however most easily prepared by action of nitric acid upon the metal: it forms insoluble compounds with ClH. Meta-stannates are not crystallizable. **Sulphides. Stannous sulphide** SSn = 150. Bluish-grey. Fusing Sn and S together. As brown hydrate by SH_2 into solution of Cl_2Sn. Soluble as S_2Sn in $S_2(NH_4)_2$. **Stannic sulphide** S_2Sn = 182. Known as "Mosaic Gold," in bright yellow flakes. As yellow hydrate by SH_2 into Cl_4Sn in solution; soluble in SHH_4N. **Stannous chloride** $Cl_2Sn,2H_2O$ in prisms. Soluble in ClH. By water into 2ClH and STANNOUS OXY-CHLORIDE $Cl_2Sn,SnO,2OH_2$. By boiling Cl_2Sn with ferric hydrate, ferrous chloride is obtained in solution, and **stannous stannate** SnO,SnO_2 as a grey hydrate. $2Cl_2Sn + Fe_2O_3 = 2Cl_2Fe +$ **SnO,SnO_2**. Reduces mercuric chloride into mercurous chloride and mercury. *a.* $2Cl_2Hg + Cl_2Sn = Cl_4Sn + Cl_2Hg_2$. *b.* $Cl_2Hg_2 + Cl_2Sn = Cl_4Sn + Hg_2$. **Stannic chloride** $Cl_4Sn,5OH_2$, in rhomboids. By adding aqua regia to stannous chloride: practically $Cl_2Sn + Cl_2 =$ **Cl_4Sn**. Also: $2Cl_2Hg + Sn =$ **Cl_4Sn** $+ 2Hg$. *Purple of Cassius.* See Gold, p. 75. **Stannous fluoride** F_2Sn, in shining prisms. **Stannic fluoride** F_4Sn, only known in **fluo-stannates.** Thus: $F_4Sn,2FK,OH_2$ is isomorphous with silico-fluoride, titano-fluoride, zircon-fluoride of potassium. Tin compounds easily reduced on charcoal in blow-pipe-flame. It is estimated as STANNIC OXIDE **SnO_2**, which contains 78.66 per cent. of tin.

[XXVI. Titanium Ti = 50.

Tetrad element, never native. Discovered by Gregor in 1791. Prismatic crystals and a dark-green powder. Sp. gr. 5.3. Burns magnificently in oxygen. *Prep.* of **Ti.** $Cl_4Ti + 2Na_2 = 4ClNa +$ **Ti.** Great affinity for nitrogen. Ti_3N_4 resembles

copper in color. $C_2N_2Ti,3N_2Ti_3$ in copper-colored cubes in certain slags from blast-furnaces. **Three oxides.** 1. **Titanous oxide** TiO, black powder, but little known. 2. **Titanic anhydride**, TiO_2 = 82. Constitutes the chief ore. "Rutile," "Brookite," and "Anatase" are TiO_2. "Menaccanite," and "Iserine," consist of ferrous titanate. Yellowish-white, and after ignition only dissolved by FH. Like SiO_2, soluble and insoluble modifications. Solution of titanic acid in ClH digested with Zn, gives a violet solution, which on addition of H_3N in excess deposits: 3. **Titanous Titanite**, TiO,TiO_2, or Ti_2O_3. TiO_2 after fusion with $SO_2(OH)(OK)$, soluble. **TiS_2** in green scales. **Titanic chloride** Cl_4Ti, fuming, volatile liquid, resembling $SnCl_4$. **Titanic fluoride** F_4Ti, colorless, fuming liquid, by water into oxy-fluoride and **hydrogen fluo-titanate** $2FH,F_4Ti$. Titanium is estimated as **TiO_2**.]

[XXVII. Zirconium Zr = 89.5.

Tetrad metal, never native. Resembling Si and Ti. A black amorphous powder, assuming some polish under the burnisher. Burns brilliantly when heated into **Zircon-oxide** ZrO_2 = 121.5. Crystalline Zr resembles antimony in appearance, and only burns in oxyhydrogen. Dissolved with ease by FH, evolving H, and forming **hydrogen fluo-zirconide** $2FH,F_4Zr$. *Prep.* of Zr: from POTASSIUM FLUO-ZIRCONIDE $2FK,F_4Zr + 2K_2 = 6FK + Zr$. **$S_2Zr$**, brown. **Zirconium oxide** ZrO_2 = 121.5. White, infusible. After ignition insoluble in acids. **OH_2ZrO_2**, gelatinous bulky-white, insoluble in caustic alkalies. When neutral solutions of its salts are boiled with one of potassium sulphate, a sparingly soluble Zirconium subsulphate separates. **SiO_4Zr** is found as "Zircon" and "hyacinth." **Cl_4Zr**, in needles, soluble in water and in alcohol.]

[XXVIII. Thorinum Th = 231.5.

Tetrad metal, never native. Discovered by Berzelius in 1828 in "Thorite," a silicate. Grey powder acquiring lustre under the burnisher. Sp. gr. 7.7 to 7.9. Dissolves easily in NO_2OH; slowly in ClH. Burns brilliantly when heated to ThO_2. *Prep.* from Cl_4Th by $2K_2 = 4ClK + Th$. THORINUM CHLORIDE, **Cl_4Th** in white, shining crystals. *Prep.* $ThO_2 + 2C + 2Cl_2 = Cl_4Th + 2CO$. **One oxide**: THORINUM OXIDE **ThO_2**, white and very heavy. Sp. gr. 9.402. THORINUM AND POTASSIUM SULPHATE $(SO_4)_4K_4Th,2OH_2$ separates as a crystalline powder from mixed sulphates, and the **hydroxide** of thorinum is precipitated by HOK, and then ignited.]

	Symbol.		At. weight.	Sp. gr.
Molybdenum . .	**Mo**	=	96 . .	8.62
Wolframium . .	**W**	=	184 . .	17.60

[XXIX. Molybdenum Mo = 96.

Dyad, tetrad and pseudo-triad, never native. White, brittle, very infusible metal. Sp. gr. 8.62. Name from *μολύβδαινα* "a piece of lead." which its ore "Molybdenite" resembles. By roasting in air, S_2Mo or **Molybdic sulphide,** becomes **Molybdic anhydride** MoO_3, and this is reduced by charcoal in a smith's forge in a crucible lined with charcoal. **Three oxides: two basic. Molybdous oxide** MoO, black. By action of H_2 (Zn and 2ClH, and ClH) upon a molybdate: reduced to $MoCl_2$ and precipitated as **hydroxide** by HOK. When heated in air, burns to **Molybdic oxide** MoO_2. Is deep-brown, and insoluble in acids. Its hydroxide dissolves readily to red solutions. From MoO_3 by reducing agents. By NO_2OH into **Molybdic anhydride** $MoO_3 = 144$. White crystalline powder, slightly soluble in water. As acid, not known in free state. MOLYBDATE OF LEAD MoO_4Pb, native, in yellow quadratic plates. $MoO_2(OH_4N)_2$, in colorless, square prisms. Solution used to detect traces of ortho-phosphoric acid; suspected liquid acidulated with NO_2OH, and molybdate added. The liquid becomes yellow, and on boiling, deposits yellow crystalline precipitate of phosphoric and molybdic acids, combined with H_3N(3 per cent. P_2O_5). **Sulphides.** MoS_2. MoS_3. MoS_4. **Chlorides.** $MoCl_2$. Mo_2Cl_6. $MoCl_4$. $MoCl_5$. Mo_2Cl_6 heated in absence of air into yellow $MoCl_2$ and brown $MoCl_4$. $MoCl_5$ by heating Mo in a stream of Chlorine, and this in a stream of H into Mo_2Cl_3.

Molybdenum is estimated as S_2Mo: contains 60 per cent. of **Mo.]**

[XXX. Wolfram, or Tungsten W = 184.

Tetrad and hexad metal, never native. Iron-grey metal of sp. gr. 17.6. Burns, when heated, into WO_3. From WO_3 by charcoal in a smith's forge. **Oxides. Tungstic dioxide** WO_2, not basic. As a brown powder by heating WO_3 with H_2. **Tungstic anhydride** $WO_3 = 232$. Forms **Tungstic acid** $WO_2(OH)_2,OH_2$ and **Metatungstic acid** $W_4O_{11}(OH)_2$. WO_3 straw-yellow powder. From "Scheelite" WO_4Ca by NO_2OH. The common mineral, "Wolfram," is $WO_4Mn,3WO_4Fe$. SODIUM TUNGSTATE is sometimes added to starch to render stiffened fabrics incombustible. **Chlorides.** WCl_4 and WCl_6 are volatile. **Sulphides** S_2W, bluish-black needles. S_3W a powerful sulphur-acid. **Sulpho-tungstates.** Thus: S_4WK_2.

Tungsten is weighed as WO_3: contains 79.31 per cent. of **W.]**

	Symbol.		At. weight.
Stibium	. **Sb**	=	**122.0**
Arsenicum	. **As**	=	**75.0**
Bismuth	. **Bi**	=	**210.0**
Vanadium	. **V**	=	**51.3**
Niobium	. **Nb**	=	**94.0**
Tantalum	. **Ta**	=	**182.0**

XXXI. Stibium or Antimony Sb = 122.

A triad and pentad element. Brilliant, bluish-white metal: flaky, crystalline (in rhombohedra, isomorphous with As), and so brittle that it may be pounded. Sp. gr. 6.7 to 6.8. Melts at 450° C. Burns brilliantly with formation of ANTIMONOUS OXIDE Sb_2O_3. By strong ClH, dissolves slowly as Cl_3Sb. NO_2OH into METANTIMONIC ACID SbO_3H. Takes fire in Cl; burns to Cl_3Sb. Chief ore "Grey antimony ore" S_3Sb_2. *Prep.* of **Sb**. $2Sb_2O_3 + 3C = 3CO_2 + 2Sb_2$. **Alloys.** "Type-metal" consists of 2 parts of Pb, one part of Sn and 1 of Sb. "Britannia metal" sometimes of 1 part of Sb and 9 parts of Sn. **Antimonide of Zinc** Sb_2Zn_3 may be used for making Stibine. **Antimonous hydride** or **Stibine** $H_3Sb = 125$. Colorless gas, burning with greenish flame to water, and antimonous oxide. With limited supply of air, burns into water, and **Sb**. Heated in a tube, into H. and a brilliant crust of Sb. The crust is easily soluble in $(H_4N)_2S_2$, and separates on evaporation as S_3Sb_2. Passed into $3NO_2OAg$, into $3NO_2OH + SbAg_3$. *Prep.* from any compound in presence of nascent H: $Cl_3Sb + 3H_2 = 3ClH + \mathbf{H_3Sb}$. $Sb_2Zn_3 + 6ClH = 3Cl_2Zn + 2\mathbf{H_3Sb}$. **Sb** with **Chlorine.** ANTIMONOUS CHLORIDE $Cl_3Sb = 228.5$. Deliquescent mass, fuses at 72° C., and boils at 223° C. Decomposed by water into ANTIMONOUS OXY-CHLORIDE ClOSb. $Cl_3Sb + OH_2 = 2ClH + ClOSb$. *Prep.* of $\mathbf{Cl_3Sb}$. *a.* $S_3Sb_2 + 6ClH = 3SH_2 + 2\mathbf{Cl_3Sb}$. *b.* $S_3Sb_2 + 3Cl_2Hg = 3SHg + 2\mathbf{Cl_3Sb}$. "Butter of antimony." ANTIMONIC CHLORIDE $Cl_5Sb = 299.5$. Volatile, colorless liquid, solid below 0° C. By OH_2 into 2 ClH + antimonic oxychloride $\mathbf{Cl_3OSb}$. By excess of water into ClH and ORTH-ANTIMONIC ACID $SbO(OH)_3$. Thus: $Cl_5Sb + 4OH_2 = 5ClH + SbO(OH)_3$. In the same manner by SH_2 into SULPHANTIMONIC CHLORIDE SCl_3Sb. *Prep* of Cl_5Sb. From $Cl_3Sb + Cl_2 = \mathbf{Cl_5Sb}$. [ANTIMONOUS BROMIDE Br_3Sb. Fuses at 90° C., and boils at 270° C. $\mathbf{I_3Sb}$ in red tables. By $OH_2 = 2IH + IOSb$. $\mathbf{F_3Sb}$.] **Sb** and **Sulphur.** *a.* ANTIMONOUS SULPHIDE $S_3Sb_2 = 340$. In granite or slate rocks In 4-sided, transversely-striated prisms, as "Stibnite." Blue or Bengal lights consist of NO_2OK 3 parts, S 2 parts and S_3Sb_2 1 part. When roasted in air, into a mixture of S_3Sb_2 with O_3Sb_2. In making antimony, after roasting, $CO(ONa)_2$ has to be added as well as charcoal for the reduction

of Sb_2O_3. Thus: $S_3Sb_2 + 3CO(ONa)_2 = 3SNa_2 + Sb_2O_3 + 3CO_2$. Then: $2Sb_2O_3 + 3C = 3CO_2 + 2$**Sb**$_2$. **$S_3Sb_2$**, of a beautiful orange color, may be obtained by precipitation: $3SH_2 + 2Cl_3Sb = 6ClH + S_3Sb_2$. Thus, too, may **$SH_2$** be manufactured. S_3Sb_2 is insoluble in ammonium carbonate: S_3As_2 is soluble. **Sulph-antimonites.** Mineral kermes is $2S_3Sb_2$, Sb_2O_3. Action of $CO(OK)_2$ on S_3Sb_2: $6[CO(OK)_2] + 3OH_2 + 3S_3Sb_2 = 6[CO(OH)(OK)] + 3SK_2 + 2S_3Sb_2, Sb_2O_3$. ANTIMONOUS OXY-DISULPHIDE S_2OSb_2, is found as red antimony ore in oblique rhombic prisms. *b.* ANTIMONIC SULPHIDE $S_5Sb_2 = 404$. Orange-red. Forms SULPH-ANTIMONATES with positive sulphides. *Prep.* $2Cl_5Sb_2 + 5SH_2 = S_5Sb_2 + 10ClH$. Also called "Sulphantimonic anhydride."—**Sb** and **Oxygen.** 1. ANTIMONOUS OXIDE $Sb_2O_3 = 292$. "White antimony ore" in prisms. Grey-white powder, yellow on heating, soluble in ClH and in TARTARIC ACID $C_2H_2(OH)_2(COOH)_2$. **Basic properties.** As hydroxide by pouring Cl_3Sb into a boiling solution of sodium carbonate. Very soluble in HOK. Burns when heated in air into ANTIMONOUS ANTIMONATE Sb_2O_3, $Sb_2O_5 = Sb_2O_4$. [METANTIMONOUS ACID $SbO(OH)$, is prepared by pouring Cl_3Sb into a cold solution of sodium carbonate: $2Cl_3Sb + OH_2 + 3CO(ONa)_2 = 6ClNa + 3CO_2 + 2SbO(OH)$. Metantimonites. By heat at $100°$: $2SbO(OH) = OH_2 + Sb_2O_3$.] 2. ANTIMONIC ANHYDRIDE $Sb_2O_5 = 324$. Pale-yellow, tasteless, insoluble powder. Obtained by oxydizing Sb with NO_2OH, washing and heating below redness. Loses oxygen at bright red-heat, and changed into **antimonous antimonate** Sb_2O_3, Sb_2O_5. ANTIMONIC ACID **SbO_3H**, can be obtained by fusing $CO(OK)_2$ with $Sb_2O_5 = CO_2 + 2$**SbO_3K**, and decomposing by ClH. By heat (2) ANTIMONIC ACID **SbO_3H** into antimonic anhydride and water. Antimonic acid also called met-antimonic acid from its analogy to metaphosphoric acid. PYR-ANTIMONIC ACID $Sb_2O_3(OH)_4 =$ **$H_4Sb_2O_7$**, is Frémy's met-antimonic acid. From $Sb_2O_3(OK)_2(OH)_2$ by $2ClH = 2ClK + Sb_2O_3(OH)_4$. DI-POTASSIUM HYDROGEN-PYRANTIMONATE precipitates Na_2 salts as insoluble $Sb_2O_3(OH)_2(ONa)_2$.

Antimony compounds yield **Sb** in brittle globules when heated on charcoal in blowpipe-flame, white vapors clouding the charcoal. Reinsch's test applicable: solution acidulated with ClH and boiled, gives a metallic deposit oxydized and dissolved by $Mn_2O_6(OK)_2$, and precipitated in acidulated solution by SH_2 as orange-coloured S_3Sb_2.

Arsenicum As = 75 (see p. 29).

XXXII. Bismuthum Bi = 210.

A triad and pentad element, chiefly native in quartz: extracted by fusion. Crystalline, and of exceeding beauty. Reddish-

white hue. Sp. gr. 9.79. Melts at 264° C. Most diamagnetic of all metals. Burns in Cl to Cl_3Bi, and when strongly heated, with bluish flame. Easily dissolved by NO_2OH, somewhat diluted. **Alloys.** "Fusible metal" consists of 8 parts of Bi, 5 parts of Pb and 3 of tin: it melts at 98° C. **Bismuthous chloride** $Cl_3Bi = 316.5$. Fusible, volatile, deliquescent. By water, into OXY-CHLORIDE **ClOBi.** Thus: $Cl_3Bi + OH_2 = 2ClH + ClOBi$. "Pearl-white" is $2ClOBi,OH_2$; insoluble in tartaric acid. *Prep.* of Cl_3Bi. Also, by distilling Bi with mercuric chloride: $Bi_2 + 6Cl_2Hg = 3Cl_2Hg_2 + 2Cl_3Bi$. [BISMUTHOUS BROMIDE Br_3Bi. IODIDE I_3Bi.] **Oxides**: one basic. 1. BISMUTH OXIDE Bi_2O_2; velvet-black. Burns into Bi_2O_3 when heated in the air. 2. **Bismuthous oxide** $Bi_2O_3 = 468$. Yellow powder, fusible at a red-heat. By heating nitrate to redness. HYDROXIDE BiO_2H or Bi_2O_3,OH_2. insoluble in KOH and in H_3N. BISMUTHOUS NITRATE $(NO_2)_3O_3Bi,5OH_2$, transparent prisms obtained by dissolving Bi in NO_2OH. Poured into water, mainly into NO_2OH, and BASIC BISMUTH NITRATE $(NO_2)_3O_3Bi,Bi_2O_3,3OH_2$. Known as "magistery of bismuth." Sometimes a larger proportion of Bi. NO_2OH,Bi_2O_3. BISMUTHOUS PHOSPHATE POO_3Bi, insoluble in dilute nitric and acetic acids. 100 parts contain 23.28 parts of P_2O_5. 3. BISMUTHIC ANHYDRIDE Bi_2O_5. Brown powder, obtained by heating bismuthic acid BiO_2OH to 132° C. BISMUTHIC ACID BiO_2OH or $HBiO_3$ red powder. Obtained by passing Cl through solution of HOK containing suspended Bi_2O_3. Thus: $Bi_2O_3 + 2Cl_2 + 4KOH = 4ClK + OH_2 + 2HBiO_3$. **Bismuth** and **S.** BISMUTHOUS SULPHIDE $S_3Bi_2 = 516$. Native as "Bismuth-glance" in needles isomorphous with S_3Sb_2. Sp. gr. 6.4. Precipitated as S_3Bi_2 of brown color by SH_2 in acid solutions, insoluble in SHH_4N.

Bi is estimated as Bi_2O_3, containing 88.74 per cent. of metal. The metal easily obtained as a brittle bead, on charcoal, in blowpipe-flame.

[XXXIII. Vanadium V = 51.3.

Pentad and triad metal, never native. Discovered in 1830 by Sefström. The metal, as obtained by Roscoe by prolonged ignition of Cl_2V in H_2 gas, is crystalline and of silvery lustre. It burns vividly in flame, forming V_2O_5. Insoluble in ClH. Burns in Cl gas to VCl_4. Analogous to N, it forms five **oxides.** V_2O, V_2O_2, V_2O_3, V_2O_4, V_2O_5. VANADIUM DIOXIDE V_2O_2 is obtained by action of K_2 upon the higher oxides. V_2O_3 by igniting V_2O_5 in a stream of H. V_2O_4 by oxydizing V_2O_2 or V_2O_3. **Vanadic anhydride** $V_2O_5 = 182.6$. Reddish-yellow color, soluble in 1000 parts of water to light-yellow solution. **Vanadates.** Meta-Pyro- and Ortho-vanadates. Easily prepared

from AMMONIUM META-VANADATE VO_2OH_4N by heat. "Vanadinite" $3(VO_4)_2Pb_3,Cl_2Pb$ is isomorphous with "Pyromorphite" $3(PO_4)_2Pb_3,PbCl_2$. **V** and **Cl**. Cl_3V, in shining tables, of peach-blossom color. By Cl_4V, Cl is evolved, and Cl_3V is obtained. Cl_2V from $2Cl_3V + H_2$ through red-hot tube. **V** and **N**. VN. VN_2. By heating VN to redness in a current of Cl, Cl_4V is obtained.]

[XXXIV. Niobium or Columbium Nb = 94.

Tetrad element, never native. Found by Hatchett in 1801 in Columbite. In its affinities, resembles Phosphorus. NIOBIC ANHYDRIDE Nb_2O_5. CHLORIDE Cl_5Nb. FLUORIDE F_5Nb. OXYFLUORIDE F_3ONb.]

[XXXV. Tantalum Ta = 182.

Pentad metal, not native. In "Tantalite" and "Yttro-tantalite" by Ekeberg. TANTALIC ANHYDRIDE Ta_2O_5. POTASSIUM TANTALIC FLUORIDE $2FK,F_5Ta$.]

		Symbol.		At. weight.		Sp. gr.		Fusing-point.
Plumbum	.	Pb	=	207.0	.	11.380	.	325°. C.
Thallium	.	Tl	=	203.6	.	11.862	.	294°. C.
Cuprum	.	Cu	=	63.4	.	8.952	.	1091°. C.
[Gallium	.	G	=	68.0	.	5.900	.	30°.1 C.]
[Indium	.	In	=	113.4	.	7.400	.	176°. C.]

XXXVI. Plumbum or lead Pb = 207.

Dyad and tetrad metal, never native. Bluish, soft, malleable, ductile, but little tenacious. Sp. gr. 11.38. Fuses at 325° C. Tarnishes slightly in damp air. Acted upon by soft water in presence of air and carbonic acid, crystals of $COO_2Pb,(OH)_2Pb$ being precipitated. Chlorides and nitrites in water also attack lead. Presence of sulphates in water best defence against lead-poisoning by water. *Acidulated*, no water fit to drink which darkens in the least degree on addition of SH_2. Lead oxydizes when melted. Dilute SO_4H_2, and ClH scarcely act. NO_2OH best solvent: $3Pb + 8NO_2OH = 3[(NO_2)_2O_2Pb] + 4OH_2 + 2NO$. **Alloys**, see Stannum, p. 61. **Oxides**: 4 known. **One basic.** 1. SUBOXIDE Pb_2O, black. 2. LEAD OXIDE or **plumbic oxide** PbO = 223. Powerful basic oxide. Yellow color. "Litharge" is fused oxide, "Massicot" unfused oxide. By the oxydation of lead in a current of air. HYDRATE $2PbO,OH_2$ is white, alkaline to test-paper, as slightly soluble, and soluble in HOK: **good test for Sulphur**. 3. MINIUM or RED LEAD, a compound of $2PbO,PbO_2$ is found native. Used as

a paint in "priming." Prepared by carefully heating lævigated lead oxide in a reverberatory furnace at 320° C. Decomposed by NO_2OH into lead nitrate and lead peroxide PbO_2. 4. **Plumbic peroxide** $PbO_2 = 239$. Native as "heavy lead ore," in iron-black, lustrous, 6-sided prisms. Absorbs SO_2 and changed into SO_2O_2Pb: **test for SO_2.** *Prep.* of PbO_2. $2PbO,PbO_2 + 4NO_2OH = 2[(NO_2)_2O_2Pb] + \mathbf{PbO_2} + 2OH_2$. Also: $(C_2H_3O)_2O_2Pb + CO(ONa)_2 + Cl_2 + 2OH_2 = 2ClNa + 2(C_2H_3O,OH) + OH_2 + CO_2 + \mathbf{PbO_2}$. LEAD SULPHIDE or **plumbic sulphide** $SPb = 239$, black. Precipitated in acid solutions by SH_2. As "galena" it is found both massive, as in cubes and dodecahedra, of leaden hue, very lustrous and very brittle. *Chief ore of lead.* **Metallurgy.** SPb is first roasted. One portion remains unchanged SPb. Another portion oxydizes into LEAD SULPHATE SO_2O_2Pb, and yet another into SO_2 and LEAD OXIDE PbO. Now, when the furnace doors are *shut*, the lead sulphate and the lead oxide react upon the unchanged lead sulphide, and give **lead** with sulphurous anhydride. Thus: $SPb + 2PbO = SO_2 + 3\mathbf{Pb}$. Again: $SO_4Pb + SPb = 2SO_2 + \mathbf{Pb_2}$. **Soluble salts of PbO.** PLUMBUM CHLORIDE Cl_2Pb, brilliant needles soluble in 135 parts of cold and 33 of boiling water. ClH precipitates soluble lead salts, when solution not too dilute. NITRATE $(NO_2)_2O_2Pb$, in white octahedra, soluble in 8 parts of cold water. Heated to redness into: $PbO + 2NO_2 + O$ (p. 10). ACETATE $(C_2H_3O)_2O_2Pb, 3OH_2$ is the "sugar of lead" of commerce. Right rhombic prisms, soluble in 2 of water. Basic acetate contains $2PbO,OH_2$. **Insoluble lead-salts. Oxy-chloride** $\mathbf{2PbO,Cl_2Pb}$, native as "Mendipite." Turner's Yellow $\mathbf{7PbO,Cl_2Pb}$. **Chlorosulphide** $\mathbf{3SPb,2Cl_2Pb}$, is precipitated white by insufficient SH_2 from Cl_2Pb. **Bromide** $\mathbf{Br_2Pb}$, white, sparingly soluble. **Iodide** $\mathbf{I_2Pb}$, yellow, soluble in boiling water, separating on cooling in golden scales. **Cyanide** $\mathbf{C_2N_2Pb}$, white. **Sulphate** $\mathbf{SO_4Pb} = 303$. White. Native as "lead vitriol" in colorless prisms and octahedra. Soluble in sulphuric acid: contained in "oil of vitriol" and precipitated white by water. **Chromate** $\mathbf{CrO_4Pb}$ yellow. Native as "Lehmannite" in oblique prisms. **Di-plumbic chromate** PbO,CrO_4Pb is vermilion-colored. **Sulphite** $\mathbf{SOO_2Pb}$, white. **Carbonate** $\mathbf{COO_2Pb}$, native as "Cerussite" in needles. "White lead" $\mathbf{(OH)_2Pb,2COO_2Pb}$. Dissolves in NO_2OH as lead-nitrate. Water must be added to ascertain whether residue of SO_4Ba. **Silicate** $\mathbf{Si(O_2Pb)_2}$. FLINT-GLASS $6SiO_2,K_2O,PbO$. SILICATE and BORATE $3(SiOO_2Pb),2B_2O_3,3PbO$. *Paste* or *Strass* for imitating gems $8SiO_2,K_2O,3PbO$.

Lead-salts are poisonous. Antidote is Glauber salt, or Epsom salt, which precipitates SO_4Pb. Lead is weighed as **lead sulphate** $\mathbf{SO_4Pb}$ containing 68.31 per cent. of metal.

XXXVII. Thallium Tl = 203.6.

A monad metal, never native. Discovered by Crookes in 1861, by the spectroscope; a single brilliant green line nearly coincident with one of the inconspicuous lines of the Barium spectrum. θαλλὸς, a budding twig. Between lead and silver in color, very heavy; of sp. gr. 11.862. Soft and malleable. Crystalline. Melts at 294° C. Tarnishes in air. Takes fire at 315° C. in oxygen and burns with green light. Combines also directly with Cl, Br, I, S and P. As chloride, but little soluble. HCl little action. With SO_4H_2 into H_2 and sulphate. Easily dissolved by NO_2OH. Forms **alloys**. *Prep.* of **Tl**, from sulphate by Zn, or electrolysis. **Three oxides.** $\mathbf{Tl_4O}$. THALLIUM OXIDE $\mathbf{Tl_2O}$, the only base. Is very soluble in water as THALLIUM HYDROXIDE **HOTl**, obtainable in pale-yellow prisms. Solution alkaline and absorbs CO_2. Precipitates Mg, Mn, &c. PEROXIDE $\mathbf{TlO_2}$, brown. THALLIUM SULPHIDE STl_2, brownish-black, by SHH_4N. **Salts.** CHLORIDE **ClTl**. Little soluble in water, yellowish-white in color. $\mathbf{Cl_6Fe_2,6ClTl}$, red crystalline. $\mathbf{2ClTl, Cl_4Pt}$. Cl_3Tl_2. Cl_2Tl. Cl_3Tl. CARBONATE $CO(OTl)_2$, in flattened prisms, soluble in 23 parts of water. NITRATE NO_2OTl, in prisms. SULPHATE $SO_2(OTl)_2$, 6-sided prisms. Forms an alum, isomorphous with K, Na, Cs, Rb, L and Ag. $\mathbf{(SO_4)_4Tl_2Al_2, 24OH_2}$. Salts poisonous.

XXXVIII. Cuprum or Copper Cu = 63.4.

This metal is a dyad in its chief compounds, and is frequently found native. It has been long known, and derives its name from Cyprus. Found native in cubes, octahedra, dendritic crystals and massive. Lustrous, malleable, ductile and tenacious. It is of a rich red color. Next to silver, the best conductor of heat and electricity. Sp. gr. 8.952. Melts at 1091° C. Corrodes but slowly in air and quite superficially; rapidly in sea-water. Heated to redness, black cupric oxide and red cuprous oxide formed. Dilute ClH and SO_4H_2 $2OH_2$ scarcely any action. NO_2OH attacks it immediately: $8NO_2OH + 3\mathbf{Cu} = 3[\mathbf{(NO_2)_2O_2Cu}] + 4OH_2 + 2NO$. Boiled with SO_4H_2: $Cu + 2SO_4H_2 = 2OH_2 + SO_2 + \mathbf{SO_4Cu}$. Leaf copper takes fire in Cl. Burns with green color in oxy-hydrogen: salts impart green color to flame. **Alloys.** BRASS $\mathbf{Cu_2Zn}$. MUNTZ METAL $\mathbf{Cu_3Zn_2}$. SPECULUM METAL $\mathbf{Cu_4Sn}$. BELL-METAL $\mathbf{Cu_6Sn}$. Bronze contains less tin. **Copper and Hydrogen.** CUPROUS HYDRIDE H_2Cu_2, by 2ClH into cuprous chloride Cl_2Cu_2. Thus: $H_2Cu_2 + 2ClH = 2H_2 + Cl_2Cu_2$. Remarkable illustration of the union of two atoms of the same element to form a molecule. At 70° C. into $H_2 + Cu_2$. **Two basic oxides** and **one peroxide.** 1. **Cuprous oxide** $Cu_2O = 142.8$. Native as "ruby copper ore." Ruby

color to glass. As yellow hydrate $4Cu_2O,OH_2$. Reducing cupric salts, we obtain cuprous salts. Solutions colorless. 2. **Cupric oxide** $CuO = 79.4$. Black: by heating the nitrate to redness. Only important oxide. HYDROXIDE $(\mathbf{OH})_2Cu$ or CuH_2O_2, light-blue. Precipitated by HOK from soluble cupric salts. Becomes black, when boiled, through loss of water. Forms salts blue or green. Is soluble in oils and fats, which may become poisonous. CuO gives a green color to glass. In presence of sugar, on boiling a cupric salt with potassium hydroxide, **cuprous oxide** Cu_2O is precipitated.—**Tri-cupric nitride** Cu_6N_2 as dark-green powder. **Sulphides.** 1. CUPROUS SULPHIDE $SCu_2 = 158.8$. As "copper glance" in 6-sided prisms. It is the "fine metal" of copper-smelters. 2. CUPRIC SULPHIDE $SCu = 95.4$. A rare mineral "Indigo copper," in flexible blue plates. As a dark-brown hydrate from cupric salts by SH_2 in acid solutions. "Copper pyrites" $\mathbf{S_2CuFe}$, is the **chief** ore of copper. Both massive, and in tetrahedra of brassy lustre. **Metallurgy.** 1. *Calcining.* Fe chiefly oxydized: S volatilized as SO_2. 2. *Melting for coarse metal.* Fe_2O_3 slagged off by SiO_2 as $Si(O_2Fe)_2$: "matt" (cuprous sulphide) SCu_2 with some S_3Fe_2 remaining. 3. *Re-calcining.* All Fe oxydized. 4. *Melting for fine metal.* Remaining Fe_2O_3 slagged off: Cu_2S remaining. 5. Roasting SCu_2 and reduction. *a.* $Cu_2S + 2O_2 = 2\mathbf{CuO} + SO_2$. *b.* $2CuO + Cu_2S = SO_2 + 4\mathbf{Cu}$. Blistered copper. 6. *Refining.* Fused in a reverberatory furnace; much Cu_2O formed, reduced by charcoal, and *poling* with trunk of a young tree. **Salts of copper.** CUPROUS CHLORIDE Cl_2Cu_2, white. By dissolving Cu in Cl_2Cu. Colorless solution; absorbs CO_2. **Cupric salts: soluble.** CHLORIDE $Cl_2Cu,2OH_2$, green deliquescent needles. Soluble in alcohol. $CuO + 2ClH = Cl_2Cu + OH_2$. CUPRIC SULPHATE $\mathbf{SO_2O_2Cu,5OH_2}$, in blue, doubly-oblique rhombs. Also with $7OH_2$, isomorphous with $SO_2O_2Fe,7OH_2$. Soluble in 4 of water. Anhydrous at 200° C., and white. Absorbs H_3N, and forms $SO_4Cu,5H_3N$. At a red-heat into $CuO + SO_2 + O$. Insoluble in alcohol. With H_3N in solution, into SO_4,H_2NCu,H_4N, a beautifully blue salt. *A test* for Cu. NITRATE $(NO_2)_2O_2Cu,6OH_2$ in blue rhomboidal prisms. ACETATE $(C_2H_3O)_2O_2Cu,OH_2$ in green, oblique-rhombic prisms. **Insoluble cupric salts. Carbonate** $\mathbf{COO_2Cu}$; not known. "Chessylite" $(OH)_2Cu,2COO_2Cu$, in oblique-rhombic prisms of blue color. "Malachite" $(OH)_2Cu,COO_2Cu$, beautifully green. Common malachite is used as an ore. By roasting into CuO, and by fuel into Cu. **Cupric arsenite** $\mathbf{As(OH)O_2Cu}$: "Scheele's Green." **Cupric hydroxyl orth-arsenate** $\mathbf{AsO(OH)O_2Cu}$, pale blue. "Verdigris" $CuO,(C_2H_3O)_2O_2Cu,6OH_2$. Copper is precipitated by steel or iron with its peculiar bright-red color. It is **weighed** as **CuO**, 100 parts of which contain 79.85 parts of **copper**.

[XXXIX. Gallium Ga = 68.

Never native. A triad, intermediate between Aluminum and Indium. Discovered in 1875 by Lecoq de Boisbaudran in a zinc-blende. Hard white metal, malleable and ductile. Sp. gr. 5.9. Melts at 30°.1 C. Heated to redness, it only oxydizes upon the surface, and does not volatilize. **Gallium oxide** Ga_2O_3 is soluble in HOK, and **Gallium** is obtained by electrolysis of this solution. Gallium oxide substitutes Alumina in alum. Gallium hydroxide is white and soluble in excess. GALLIUM CHLORIDE Cl_3Ga is deliquescent. GALLIUM SULPHIDE S_3Ga_2 is white, and precipitated from its salts by SHH_4N.

Gallium gives a bright **spectrum**, exhibiting a brilliant line and a fainter band in the violet. 'Watts' Chemistry.']

[XL. Indium In = 113.4.

Never native. A triad. Discovered in 1863 by Reich and Richter in the zinc-blende of Freiberg. Silver-white metal, malleable and ductile. Sp. gr. 7.421. Melts at 176° C. Less volatile than Cadmium. Heated to redness it burns with violet flame In_2O_3. CHLORIDE **Cl_3In**, volatile. SULPHIDE S_3In_2 is yellow. Precipitated from neutral solutions by SH_2. INDIUM OXIDE In_2O_3 yellow; Hydroxide is white, soluble in HOK, insoluble in H_3N. Zn and Cd precipitate Indium.

Two indigo-colored lines, in the **spectrum**: one very bright and more refrangible than the blue line of Sr, the other fainter and still more refrangible, and approaching the blue line of Potassium. 'Watts.']

	Symb.		At. weight.	Sp. gr.	Fusing-point.
Argentum	**Ag**	=	**108.0**	**10.53**	**916°. C.**
Hydrargyrum	**Hg**	=	**200.0**	**13.59**	**38°.8 C.**
Aurum	**Au**	=	**196.6**	**19.34**	**1037°. C.**
Platinum	**Pt**	=	**197.1**	**21.53**	**1460°. C.**
Palladium	**Pd**	=	**106.5**	**11.80**	**1360°. C.**
[Rhodium	**Ro**	=	**104.3**	**12.10]**	
[Ruthenium	**Ru**	=	**104.2**	**11.40]**	
[Osmium	**Os**	=	**199.0**	**21.40]**	
[Iridium	**Ir**	=	**198.0**	**21.15]**	

XLI. Argentum or Silver Ag = 108.

Monad metal, frequently native, both crystallized and massive. The whitest and most lustrous of the metals. The best conductor of heat and electricity. Sp. gr. 10.53. Melts at 916° C. A noble metal; does not tarnish in pure air, and its oxide is

reduced by heat alone. When heated it absorbs mechanically 22 times its bulk of oxygen, and "spits" on cooling. Great affinity for S. ClH does not dissolve it. NO_2OH its great solvent: $Ag_2 + 3NO_2OH = OH_2 + NOOH + 2\mathbf{NO_2OAg}$. Boiled with $SO_2(OH)_2$: $Ag_2 + 2SO_2(OH)_2 = 2OH_2 + SO_2 + \mathbf{SO_2(OAg)_2}$. **Alloys.** Ag_3Cu_2. Our silver coinage contains 7.5 per cent. of copper and has a sp. gr. of 10.30. ASSAYING by CUPELLATION. English coin requires $5\frac{1}{2}$ times its weight of lead for cupellation: the base metal oxydizes and is absorbed by the cupel (bone-earth). **Oxides. Three oxides: one basic.** 1. ARGENTOUS OXIDE Ag_4O, very unstable. 2. ARGENTIC OXIDE $\mathbf{Ag_2O}$, = 232, brown. Powerful base. From the HYDROXIDE HOAg at 60° C. *Prep.* $NO_2OAg + HOK = NO_2OK + HOAg$. Then: $2HOAg = OH_2 + OAg_2$. Soluble in H_3N. Slightly in water. At a low red-heat into $2Ag_2 + O_2$. **Salts.** 3. PEROXIDE Ag_2O_2. Dark-grey needles, by electrolysis of NO_2OAg. **Sulphides.** ARGENTIC SULPHIDE $\mathbf{SAg_2}$ = 248. Native as "silver glance" in cubes and in octahedra. Also in "red silver ore" $S_3Sb_2,(SAg_2)_3$. Is precipitated from its soluble salts even in acid solutions by SH_2. **Metallurgy.** Ore containing SAg_2, S_2Fe, S_2FeCu, is roasted with ClNa. $SAg_2 + 2ClNa + 2O_2 = SO_4Na_2 + 2\mathbf{ClAg}$. $SCu + 2O_2 = SO_4Cu$. $2SCu + 4ClNa + 4O_2 = 2SO_4Na_2 + Cl_2 + 2Cl_2Cu_2$. $2S_2Fe + 6ClNa + 7O_2 = 3SO_4Na_2 + Cl_6Fe_2 + SO_2$. The mass, pounded, is mixed with water in a revolving cask, then scrap iron added, and after sufficient time to convert Cl_6Fe_2 + Fe into $3Cl_2Fe$; Cl_2Cu_2 + Fe into $Cl_2Fe + Cu_2$; SO_4Cu + into SO_4Fe + Cu, and lastly $2\mathbf{ClAg}$ + Fe into $Cl_2Fe + \mathbf{Ag_2}$; **Mercury** is added, and the **amalgam** formed with the reduced **Ag** and **Cu**, washed, strained and heated. **Ag** with **Cu** remains. **Salts of silver: soluble in water.** ARGENTIC NITRATE NO_2OAg = 170. Square, colorless, anhydrous tables. Melts at 219° C. Cast into sticks; "lunar caustic." Very soluble in water. Also soluble in boiling alcohol. If made from copper containing silver, $(NO_2)_2O_2Cu$ is first decomposed by heat, and OCu can be removed by filtration. Reduced by heat. ARGENTIC SULPHATE SO_4Ag_2 = 312. Small rhombic prisms, soluble in 90 of cold water. Absorbs $4H_3N$. SILVER ALUM $(SO_4)_4Ag_2Al_2,24OH_2$. ACETATE $C_2H_3O(OAg)$, thin silken needles. FLUORIDE FAg, very soluble. POTASSIUM-ARGENTIC CYANIDE $2(CNK,CNAg),OH_2$ in rhombic prisms. Used in electro-plating. **Soluble silver salts are irritant poisons: antidote ClNa. Insoluble silver salts. Argentic chloride** ClAg = 143.5. Native as "horn silver" in cubes. Melts at 260° C. Easily reduced by Zn and Fe. Also by H_2 at a moderate heat. **NB.** Solutions of Cu and Ag can have Ag removed as insoluble ClAg, and the latter decomposed by Zn. $2ClAg + Zn = Cl_2Zn + Ag_2$. When ClAg is fused with sodium carbonate: $4ClAg + 2CO(ONa)_2 = 4ClNa + 2CO_2 + O_2 + 2Ag_2$. ClAg absorbs H_3N

largely, and gives it up on application of heat. It is also very soluble in liquor ammoniæ. **Argentum bromide** $BrAg$, yellowish; soluble in much liquor ammoniæ. **Iodide** IAg, yellow: insoluble in H_3N. All three insoluble in NO_2OH. Native as "iodite." **Cyanide** $CNAg$, white. Soluble in H_3N and in strong NO_2OH. **Thiosulphate** $S_2O(OAg)_2$ white, decomposing into $Ag_2 + S + SO_4H_2$ with OH_2. **Orthophosphate** $PO(OAg)_3$, bright-yellow, soluble in H_3N and in NO_2OH. **Pyrophosphate** $P_2O_3(OAg)_4$, white. **Metaphosphate** PO_2OAg, white, soluble in H_3N and in NO_2OH. **Arsenite** $As(OAg)_3$, yellow, soluble in H_3N and NO_2OH. **Arsenate** $AsO(OAg)_3$, liver-brown, and soluble in H_3N and NO_2OH. **Borate** $BO(OAg)$ white. **Chromate** CrO_4Ag_2 crimson.

The metal Silver easily obtained in globules. Precipitated from its solutions as **silver chloride** $ClAg$, 100 parts of which contain 75.26 of the metal. It is weighed as chloride.

XLII. Hydrargyrum Hg = 200.

A dyad metal, rarely native. The molecule of the vapor, equal two vols., contains only one atom like Zn, Cd, &c. A noble metal, which does not tarnish, and whose oxides are reduced by heat alone. Its name from ὕδωρ, water, and ἄργυρον, silver, from its fluid state and lustre like silver. Fluid above 38°.8 C. Sp. gr. 13.59. Boils at 357° C. Forms **amalgams** with the metals. **AgHg. CuHg.** Zn_2Hg. Pb_2Hg. **FeHg.** Sn_7Hg. Hydrogen chloride does not attack Hg. With SO_4H_2. $2SO_4H_2 + Hg = SO_4Hg + 2OH_2 + SO_2$. With nitric acid: $3Hg + 8NO_2OH = 3[(NO_2)O_2Hg] + 4OH_2 + 2NO$. Combines directly with Cl, Br, I and S. Used for silvering mirrors, and for extracting Au and Ag. Heated to 300° C., slowly into HgO. **Sulphides.** MERCUROUS SULPHIDE SHg_2 black, and unstable. From salts by SH_2. MERCURIC SULPHIDE **SHg** = 232 = 3 vols. Native as Cinnabar in hexahedral prisms: the **chief ore.** Vermilion is artificial SHg. It is precipitated black by SH_2 from its salts, insoluble in NO_2OH. **Metallurgy.** *a.* By washing and collecting the metal. $SHg + O_2 = SO_2 + \mathbf{Hg}$. *b.* $SHg + Fe = SFe + \mathbf{Hg}$. *c.* $4SHg + 4CaO = 4\mathbf{Hg} + SO_4Ca + 3SCa$. **Oxides; 2 basic.** I. MERCUROUS OXIDE OHg_2 = 416, black, unstable. From $Cl_2Hg_2 + 2HOK = 2ClK + OH_2 + \mathbf{OHg_2}$. Decomposed by light into $Cl_2Hg + Hg$. 2. MERCURIC OXIDE **OHg** = 216. Red crystalline powder. "Red oxide" from which O first prepared. *Prep.* also by decomposing $(NO_2)_2O_2Hg_2$ by heat. Ammonia upon mercuric oxide: MERCURAMINE HYDRATE $N_2Hg_4(OH)_2,4OH_2$. Yellowish-white, and decomposed by light. Absorbs CO_2. Unites with acids to form salts. **Salts. Mercurous. Soluble in water.** MERCUROUS NITRATE $(NO_2)_2O_2Hg_2,2OH_2$ in efflorescent prisms. ACETATE $(C_2H_3O)_2O_2Hg_2$, in silvery

scales, soluble in boiling water. **Insoluble in water. Mercurous chloride** Cl_2Hg_2 = 471 = 4 volumes. "Calomel." In 4-sided prisms, or as a yellowish-white powder. By Lime-water into "black-wash" Hg_2O. By H_3N into ClH_2Hg_2N. Thus: $2H_3N + Cl_2Hg_2 = ClH_4N + ClH_2Hg_2N$; or ammonium chloride in which Hg_2 substitutes H_2. *Prep.* of calomel. By subliming a mixture of $2ClNa + SO_4Hg_2 = Cl_2Hg_2 + SO_4Na_2$. **Bromide** Br_2Hg_2. **Iodide** I_2Hg_2 green. By light into I_2Hg + Hg. **Chromate** $Hg_2O,3CrO_4Hg_2$. **Soluble mercuric salts.** MERCURIC CHLORIDE Cl_2Hg = 271. "Corrosive sublimate." In needles soluble in 16 of cold and 3 of boiling water. Fuses at 265° C., and boils at 295° C. Violent acrid poison: antidote egg-albumen. Coagulates albumen, hence its use *also* in kyanizing timber. Forms double salts with ClK, ClNa, ClH_4N. *Prep.* of corrosive sublimate. By subliming a mixture of $2ClNa + SO_4Hg = SO_4Na_2 + Cl_2Hg$. "White precipitate" is **Chloro-amide of mercury** ClH_2HgN. Thus: $2H_3N + Cl_2Hg = ClH_4N + ClH_2HgN$. **Chloro-sulphide** $Cl_2Hg,2SHg$, white and precipitated by SH_2 when Cl_2Hg in considerable excess. Both chloro-amide and chloro-sulphide of mercuric are insoluble in water. BROMIDE Br_2Hg, crystalline. CYANIDE C_2N_2Hg, rectangular prisms, soluble in 8 of water. By heat into Hg, C_2N_2, and paracyanogen. MERCURIC OXY-CYANIDE C_2N_2Hg,HgO, in needles. MERCURIC NITRATE $2[(NO_2)_2O_2Hg].OH_2$. MERCURIC SULPHATE SO_4Hg, white crystalline powder. **Insoluble salts, Chloro-amide. Chloro-sulphide. Mercuric oxy-chlorides,** by the action of CO(OH)(OK) upon Cl_2Hg, or by boiling HgO with Cl_2Hg. **2HgO,Cl_2Hg. 3HgO,Cl_2Hg. 4HgO,Cl_2Hg. Mercuric iodide** I_2Hg = 454. Scarlet, and readily soluble in excess of IK. **Mercuric ammonium iodide** IHg_2N,OH_2 is brown. It is occasioned by the use of Nessler's test (a solution of mercuric iodide in potassium iodide, to which potassium hydroxide has been added) to a liquid containing H_3N. **Basic mercuric sulphate** $SO_4Hg,2HgO$ is yellow. "Mineral turpeth." **Basic mercuric nitrate** $(NO_2)_2O_2Hg,2HgO,OH_2$, yellow. Salts of mercury are readily reduced to metallic state by Cu, or by heating the dry compounds with $CO(ONa)_2$. Stannous chloride may be used (see Cl_2Sn). The metal is weighed as **mercury.**

XLIII. Aurum Au = 196.6.

This triad metal is always found native, both massive and crystallized in cubes, octahedra and tetrahedra. In California, Australia, Ural Mountains, &c. Bright yellow, lustrous metal, of sp. gr. 19.34. The most malleable of all metals; gold-leaf $\frac{1}{200000}$ of an inch in thickness. Inferior to Ag and Cu in conductivity. Melts at 1037° C. Untarnishable in air. A noble

metal, as its oxide becomes metallic by heat alone. Only attacked by Cl, Br, I. $Au_2 + 2Cl_3 = 2Cl_3Au$. Standard gold is alloyed with 8.33 per cent. of Cu: alloy harder and more fusible than pure gold. Ag separated by "quartation" process, *i.e.* fusion with Ag so as to reduce the gold to $\frac{1}{4}$, and employing NO_2OH for solution of the Ag as NO_2OAg: gold left as a brown powder. **Two chlorides. Aurous chloride** $ClAu = 232.1$. Pale yellow, sparingly soluble powder, losing all its Cl at 200° C. Prepared from Cl_3Au by heat at 175° C. **Auric chloride** $Cl_3Au = 303.1$. Red, deliquescent salt, by dissolving Au in aqua regia, and evaporation below 120° C. Solution orange, or yellow when dilute. By heat into $Cl_2 + ClAu$, and then into Cl and Au. Easily reduced by P_2, Cu, Hg, Zn, Fe, &c. Also by SO_4Fe. Thus: $6SO_4Fe + 2Cl_3Au = Cl_6Fe_2 + 2[(SO_4)_3Fe_2] + \mathbf{Au_2}$. Also by OXALIC ACID $C_2O_2(OH)_2$. Thus: $2Cl_3Au + 3C_2O_2(OH)_2 = 6ClH + 6CO_2 + 2\mathbf{Au}$. Also by ANTIMONOUS CHLORIDE Cl_3Sb. Thus: $2Cl_3Au + 3Cl_3Sb = 3Cl_5Sb + \mathbf{Au_2}$. Also by SULPHUROUS ACID $SO(OH)_2$. Thus: $2Cl_3Au + 3OH_2 + 3SO(OH)_2 = 6ClH + 3SO_2(OH)_2 + \mathbf{Au_2}$. Used as a test for tin. "Purple of Cassius" $Au_2Sn, Au_6Sn_2, 4OH_2$. **Two oxides.** 1. AUROUS OXIDE $\mathbf{Au_2O} = 409.2$. Green powder; with H_3N "fulminating gold." By HOK from aurous chloride. 2. AURIC OXIDE $Au_2O_3 = 441.2$. Brown powder. Or, as yellow HYDRATE $\mathbf{Au_2O_33OH_2}$, if precipitated by $Mg(OH)_2$ from $2Cl_3Au$, and excess of MgO removed by dilute NO_2OH. At 245° C. into $Au_2 + O_2$. Properties of an acid. **Aurates.** $\mathbf{AuO(OK),3OH_2}$. **Sulphides.** AURIC SULPHIDE $\mathbf{S_3Au_2}$. deep yellow. By passing SH_2 through dilute Cl_3Au. AUROUS-AURIC SULPHIDE $\mathbf{SAu_2,S_3Au_2}$. Black. Soluble in alkaline sulphides to sulphur salts. *E.g.* $4SAuNa, 2S_2Na_2$. Gold is used for staining glass ruby-red, and as "Burgos lustre" a double sulphide of Gold and Potassium, for gilding china. It is weighed as Gold.

XLIV. Platinum Pt = 197.1.

A tetrad metal, always found native, and as an alloy with Palladium, Osmium, Iridium, Rhodium and Ruthenium in the Ural Mountains, Brazil and Ceylon. Discovered by Wood in 1741. White lustrous metal, very malleable and ductile. Sp. gr. 21.53. Melts at 1460° C. A noble metal: its oxides, by heat, into Pt and O. Aqua regia dissolves it as Platinic chloride, and it is precipitated from its solutions quantitatively, by ammonium chloride as AMMONIUM-PLATINIC CHLORIDE $2(ClH_4N),Cl_4Pt$. By heat into $2ClH_4N + Cl_2 + \mathbf{Pt}$. Thus is "spongy platinum" prepared. Another form of more finely divided platinum, "platinum black," is obtained by boiling a solution of platinous chloride in strong HOK, and adding alcohol. In these conditions it

condenses O in its pores: "Doberciner lamp." **Alloys.** Lead and Bismuth to be avoided in vessels of platinum, or on platinum foil. Also phosphorus, or phosphates, with reducing agents. **Chlorides.** 1. PLATINOUS CHLORIDE Cl_2Pt = 268. Of olive color, insoluble in water. Crystallizable double salts with 2ClK, 2ClNa, &c. By heating Cl_4Pt at 235° C. as long as Cl_2 is expelled. 2. PLATINIC CHLORIDE Cl_4Pt = 339. Red-brown, deliquescent prisms. Unites with, $2ClH,Cl_4Pt, 6OH_2$. Also with, $2ClK,Cl_4Pt$: $2ClH_4N,Cl_4Pt$. Also with, 2ClCs, 2ClRb, 2ClL. All of these salts sufficiently insoluble to enable us to determine the respective metals.—[Basic ammoniacal derivatives from the chlorides. PLATOSAMINE PtH_4N_2,OH_2. DIPLATOSAMINE $PtH_{10}N_4,2OH_2$. PLATINAMINE $PtH_2N_2,4OH_2$. DIPLATINAMINE HYDROCHLORIDE $PtH_8N_4 2ClH$ (base not isolated), &c.] **Oxides.** 1. PLATINOUS OXIDE PtO = 213. Black hydrate. From Cl_2Pt by 2HOK. 2. PLATINIC-OXIDE PtO_2 = 229. As brown HYDRATE $2OH_2,PtO_2$. Soluble in HOK. Salts well characterized. **Sulphides.** 1. PLATINOUS SULPHIDE SPt: black. 2. PLATINIC SULPHIDE S_2Pt. Brown-black. Somewhat soluble in alkaline sulphides.

Platinum may be weighed, either as **Pt**, or as $2ClH_4N,Cl_4Pt$ which contains 44.17 per cent. of the **metal**.

[XLV. Palladium Pd = 106.5.

A dyad metal, discovered by Wollaston in 1803. Occasionally native in cubes and hexagonal plates. Usually forms ½ to 1 per cent. of the Platinum ores. **Pd** may be separated from all metals except Pb and Cu, by C_2N_2Hg. Ignited, leaves Palladium. From palladium ores, after conversion into chlorides, and the removal of Platinic chloride by $2ClH_4N$, MERCURIC CYANIDE C_2N_2Hg precipitates PALLADIOUS CYANIDE C_2N_2Pd. In a solution containing the nitrates of Pb, Cu, Fe_2 and Pd, ferric and plumbic are precipitated by H_3N, and the ammoniacal solution containing ammonia compounds of Cu and **Pd**, is precipitated by ClH; PALLADAMINE HYDROCHLORIDE $Cl_2H_6N_2Pd$ as a yellow, sparingly soluble salt is separated from which the metal is obtained by heat. White, hard and lustrous. Noble metal: its oxides into metal and oxygen by heat. Sp. gr. 11.8. Melts at 1360° C. Dissolved by NO_2OH. Metallic palladium takes up 982 times its volume of Hydrogenium, forming an alloy. From its increase in bulk by the absorption of H, which the Palladium undergoes when placed as the negative electrode in acidulated water, the density of the metal Hydrogenium is ascertained to be 0.733. **Chlorides.** 1. PALLADOUS CHLORIDE Cl_2Pd = 177.5. By evaporation of solution of Pd in aqua regia. Brown hydrate. With H_3N a series of basic compounds like those with Pt. Thus PALLADAMINE PdH_6N_2O. 2. PALLADIC

CHLORIDE **Cl_4Pd**. Only in solution. 2**ClK,Cl_4Pd** in ruby-red crystals. PALLADOUS IODIDE **I_2Pd**, a black powder. PALLADOUS CYANIDE **C_2N_2Pd** yellow. Forms soluble double cyanides. **Oxides: 3. Pd_2O. PdO. PdO_2.** PALLADOUS OXIDE **PdO** = 122.5 is the chief oxide. Black powder. Also as hydrate by HOK from palladous salts. **Sulphides: three.** Pd_2S. **PdS**. PdS_2. PALLADOUS SULPHIDE **SPd**. Precipitating Cl_2Pd by SH_2.

Palladium, precipitated as cyanide, is weighed as **Palladium.**]

[XLVI. Rhodium Ro = 104.3.

A triad metal found as an alloy of Platinum, constituting about ½ per cent. Discovered by Wollaston in 1803. Obtained from 3**$ClNa,Cl_3Ro$**,9**OH_2**, by solution in water, and precipitation by bars of zinc. White malleable metal, of sp. gr. 12.1. Salts rose-red from ῥόδον. **Rhodium chloride** Cl_3R. By igniting R in Cl. **Oxides: 4 oxides. One base. Rhodic oxide** R_2O_3 = 256.6. Greenish-grey hydrate. **Sulphides:** two. RoS. Ro_2S_3.]

[XLVII. Ruthenium Ru = 104.2.

A triad, never native but in an alloy of Os, Ir, Ru, and R. Discovered by Claus in 1845. Hard, brittle, most infusible metal. Sp. gr. 11.4. Oxydized when heated, or by fusion with NO_2OK. **Three chlorides. $RuCl_2$. $RuCl_3$. $RuCl_4$. Sulphides.** SRu. S_3Ru_2. S_3Ru. **Oxides.** RuO. **Ru_2O_3**. RuO_2. RuO_3. RuO_4.]

[XLVIII. Osmium Os = 199.

Discovered by Tennant in 1803 in Osmium-Iridium-Ruthenium. Bluish-white metal of sp. gr. 21.4. Very infusible. Burns to **Osmium tetroxide** OsO_4. From $OsO_4 + 8Hg + 8ClH = 4OH_2 + 4Cl_2Hg_2 +$ **Os**. From the pungent, irritating odor of OsO_4, it has its name from ὀσμή, smell. **Four chlorides. Cl_2Os. Cl_3Os. Cl_4Os. Cl_6Os.** TETRACHLORIDE Cl_4Os. Red, crystalline, fusible deliquescent sublimate. **Five oxides.** OsO. Os_2O_3. OsO_2. OsO_3. OsO_4. **Osmium tetroxide** OsO_4 = 263. Colorless needles, very soluble in water. Vapor irritating and poisonous. SH_2 in HCl, precipitates black hydrated **sulphide**, S_4Os.]

[XLIX. Iridium Ir = 198.

Sometimes native. Discovered by Tennant in 1803. Usually as an alloy with Os. White brittle metal of sp. gr. 21.15.

From $2ClK,Cl_4Ir$, heated in a stream of H_2; ClK removed by washing. Three chlorides. Cl_2Ir. Cl_3Ir. Cl_4Ir. Three oxides. IrO. Ir_2O_3. IrO_2. Three sulphides. SIr. S_2Ir_3. S_2Ir. From the changes of color, owing to the rapidity with which the oxides pass into one another, the name Iridium was given, from *Iris*.]

END OF INORGANIC CHEMISTRY.

ORGANIC CHEMISTRY.

ORGANIC CHEMISTRY is the *Chemistry of Carbon compounds*, **Carbon** being the most characteristic constituent of all vegetable and animal matters. Thus, when any organized structure is heated out of contact with air, it blackens, owing to the presence of unburnt carbon. Most carbon compounds contain only a few elements. They consist either of **Carbon and Hydrogen**; **Carbon and Oxygen**; **Carbon, Hydrogen** and **Oxygen**; **Carbon** and **Nitrogen**; **Carbon** and **Sulphur**; **Carbon, Nitrogen**, and **Hydrogen**; **Carbon, Hydrogen, Oxygen** and **Nitrogen**, sometimes even of **C, H, N** and **O** with **Sulphur** and **Phosphorus.**

Many organic **compounds** are made by **synthesis**, in the same way as are inorganic.

We have already learnt that the atoms of different bodies differ in their **quantivalence** (p. 2). As Hydrogen forms the most simple compounds, it is best adapted for ascertaining the quantivalence of other elements, of which those forming volatile hydrides can be divided into four groups:

$$1.\ \left.\begin{matrix}H\\H\end{matrix}\right\}\ \left.\begin{matrix}Cl\\H\end{matrix}\right\}\ \left.\begin{matrix}Br\\H\end{matrix}\right\}\ \left.\begin{matrix}I\\H\end{matrix}\right\}\ \left.\begin{matrix}F\\H\end{matrix}\right\} \qquad 2.\ O\left\{\begin{matrix}H\\H\end{matrix}\right.\ S\left\{\begin{matrix}H\\H\end{matrix}\right.\ Se\left\{\begin{matrix}H\\H\end{matrix}\right.\ Te\left\{\begin{matrix}H\\H.\end{matrix}\right.$$

$$3.\ \left.\begin{matrix}H\\H\\H\end{matrix}\right\}N\ \left.\begin{matrix}H\\H\\H\end{matrix}\right\}P\ \left.\begin{matrix}H\\H\\H\end{matrix}\right\}As\ \left.\begin{matrix}H\\H\\H\end{matrix}\right\}Sb. \qquad 4.\ \left.\begin{matrix}H\\H\\H\\H\end{matrix}\right\}C\ \left.\begin{matrix}H\\H\\H\\H\end{matrix}\right\}Si.$$

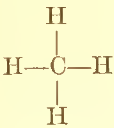
Thus we find **H, Cl, Br, I** and **F** are MONADS; **O, S, Se** and **Te**, DYADS; **N, P, As** and **Sb**, TRIADS; **C** and **Si**, TETRADS.

The smallest particle of such compounds consists of a coalition of atoms, called a **molecule**. As the densities of all gases and vapors are equal to half their molecular weights, equal volumes of different gases always contain the same number of molecules; so that any molecule, in the gaseous or vaporous condition, occupies the same space as two parts by weight of hydrogen.

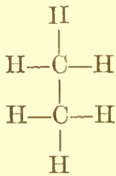
Carbon is a tetrad element; its most simple compound is METHANE CH_4. By substitution of other monads, we obtain CH_3Cl; CH_2Cl_2; $CHCl_3$; CCl_4. By replacing the monads by

dyads, we obtain $\mathbf{CO_2}$; $\mathbf{CS_2}$; with triads, **CNH**. When **two atoms** of **carbon** unite with each other, two out of the eight units of combining capacity saturate each other, so that the result is a **hexad** group; when **three atoms** of **carbon** are thus linked together, we obtain an **octad** group.

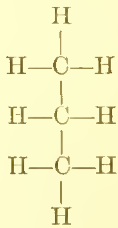
$\mathbf{CH_4}$



$\mathbf{C_2H_6}$



$\mathbf{C_3H_8}$



Of course **Cl**, **Br**, **I**, &c., may be substituted for **one atom** of HYDROGEN, but **O** and **N** can only substitute respectively **two** and **three atoms** of HYDROGEN. The **monad groups** (**OH**) and ($\mathbf{NH_2}$) can replace **one atom** of hydrogen. Thus:

$C\,H_3$**OH** is METHANE $C\,H_4$ in which **OH** substitutes **H**.
C_2H_5**OH** is ETHANE C_2H_6 in which **OH** substitutes **H**.
C_3H_7**OH** is PROPANE C_3H_8 in which **OH** substitutes **H**.

So we have a number of compounds in a series, each of which differs from the next by $\mathbf{CH_2}$; **homologous**, analogy of constitution, with a difference in composition of $\mathbf{CH_2}$, or a multiple of CH_2.

When the different members of a homologous series are submitted to similar chemical reagents, they furnish derivative series in which the homology is still preserved; such collateral series are called **heterologous**, *e.g.*:

$C\,H_4$	$C\,H\,OH$	$C\,H\,O.OH$	$C\,H_2O.$
C_2H_6	C_2H_5OH	$C_2H_3O.OH$	$C_2H_4O.$
C_3H_8	C_3H_7OH	$C_3H_5O.OH$	$C_3H_6O.$

When the successive terms of a series differ only by $\mathbf{H_2}$ we have an **isologous** series. Thus:

ETHANE	C_2H_6	ETHENE	C_2H_4	ETHINE	C_2H_2		
PROPANE	C_3H_8	PROPENE	C_3H_6	PROPINE	C_3H_4	PROPONE	C_3H_2

Each vertical column forms a HOMOLOGOUS, and each horizontal line an ISOLOGOUS series.

All hydrocarbons contain an even number of atoms of hydrogen, as a consequence of the tetrad character of the element carbon. Further, it follows that the sum of the atoms of monad

and triad elements, contained in the molecule of a carbon compound, must also always be an even number.

Carbon compounds having the same percentage composition, but differing in their physical and chemical properties, are called **isomeric**. All true isomeric compounds contain the same number of carbon atoms linked together. **Polymeric** bodies are such as have the same percentage composition but different molecular weights. ETHENE C_2H_4, PROPENE C_3H_6, and BUTENE C_4H_8 are polymeric. **Metameric** bodies have the same percentage composition and the same molecular weights, *e.g.*:

$$N\left\{\begin{matrix}C_3H_7\\H\\H\end{matrix}\right. \qquad N\left\{\begin{matrix}CH_3\\C_2H_5\\H\end{matrix}\right. \qquad N\left\{\begin{matrix}CH_3\\CH_3\\CH_3\end{matrix}\right.$$

Here we have C_3H_9N, constituting three metameric bodies in which different radicles are linked together by the same polygenic element.

Most carbon compounds are liquid or solid. The more volatile a substance, the more simple is its constitution. In homologous series the boiling-point must rise by each added CH_2; in some cases it does so with great regularity. In the normal alcohols there is a regular difference of 19° C. between each. Thus ETHYL ALCOHOL $\mathbf{C_2H_5OH}$, boils at 78°.4; PROPYL ALCOHOL $\mathbf{C_3H_7OH}$, at 97°; BUTYL ALCOHOL $\mathbf{C_4H_9OH}$, at 116° C.

When the difference in the boiling-points of two bodies is considerable, it is possible, when mixed together, to separate them by **fractional distillation**: the more volatile body distils at a nearly constant temperature.

The determination of the composition of carbon compounds is by **organic analysis**. A known weight of the body to be analyzed is burnt in contact with an easily reducible metallic oxide, generally **cupric oxide**. The **Carbon** is burnt into **carbonic anhydride** $\mathbf{CO_2}$, and the **Hydrogen** into water $\mathbf{OH_2}$. The resulting compounds are collected and weighed. **Nitrogen** is determined by heating with soda-lime and collecting the **Ammonia** $\mathbf{H_3N}$ in ClH, and weighing as AMMONIUM PLATINIC CHLORIDE $\mathbf{2ClH_4N,Cl_4Pt}$. If the Nitrogen cannot be completely converted into H_3N, it must be separated in the free state, and collected over mercury. **Oxygen** is estimated by the **loss**. Compounds containing **Chlorine, Bromine** and **Iodine** are heated in a narrow combustion-tube with pure CALCIUM OXIDE. **Sulphur** and **Phosphorus** are determined by heating the carbon compound with SODIUM CARBONATE and POTASSIUM NITRATE, or even by OXYDATION with NITRIC ACID in sealed tubes. In both cases, the **sulphuric** and **phosphoric acids** are estimated by common analytical methods. In a similar manner are bodies treated which contain **Arsenicum, Boron, Silicon,** &c. In metallic salts

of organic compounds, ignition occasions either the separation of metal, of oxide, or of carbonate. The empirical formula of a compound is easily obtained by dividing the percentage composition by the respective atomic weights. Thus with carbonyl **CO**. It consists of:

Carbon	42.858
Oxygen	57.142
	100.000

Now $42.858 \div 12 = 3.571$, and $57.142 \div 16 = 3.571$. It is therefore obvious that the simplest formula for carbonyl is **CO**, composed of one atom respectively of **Carbon** and of **Oxygen**.

For determining the vapor-density, we ascertain either the weight of a given volume of vapor (Dumas' process), or the volume of a given weight of vapor (Gay-Lussac's).

I. Mono-carbon or Methane group.

Methane CH_4 = 16. Found as fire-damp and marsh-gas. Colorless, inodorous gas, little soluble, inflammable with scarcely luminous flame. Sp. gr. 8. A mixture of $CH_4 + 2Cl_2$ explodes in sunlight to $4ClH + C$. By diffused light into CH_3Cl, CH_2Cl_2, $CHCl_3$ and CCl_4. *Prep.* p. 11. Also by nascent $\mathbf{H_2}$ upon **trichlormethane** or chloroform. $CHCl_3 + 3H_2 = 3ClH + \mathbf{CH_4}$. Again by $2OH_2$ upon ZINC METHIDE $Zn(CH_3)_2$ = ZINC HYDROXIDE $Zn(OH)_2 + \mathbf{CH_4}$. Methane is the first of the **paraffins** C_nH_{2n+2}; it is a saturated hydrocarbon which cannot unite directly with Cl, Br, I and other monads. It may however take up any number of dyad elements or radicles, because such a radicle introduced into any group of atoms neutralizes one unit of equivalency, and adds another. Thus **methane** is the **first** of an **homologous series** of **paraffins**. $CH_4CH_2 = \mathbf{C_2H_6}$, or one atom of H displaced by CH_3. *E.g.* $\mathbf{CH_4}$; C_2H_6, p. 91; C_3H_8, p. 100; C_4H_{10}, p. 104; C_5H_{12}, p. 106; C_6H_{14}, p. 108, &c. Methane may be deprived of a molecule of $\mathbf{H_2}$, and give rise to a **dyad radicle**, the first of an homologous series $\mathbf{CH_2}$; $\mathbf{C_2H_4}$; $\mathbf{C_3H_6}$; $\mathbf{C_4H_8}$. *a.* **Chloromethane** or **methyl chloride CH_3Cl**. Colorless gas, of sweetish taste, but little soluble in water. Burns with pale flame. *Prep.* 1. From methane, by Cl_2 in diffused daylight. Also by distilling methyl alcohol with sodium chloride and sulphuric acid. $CH_3OH + ClNa + SO_2(OH)_2 = SO_2(OH)(ONa) + OH_2 + \mathbf{CH_3Cl}$. Successively by chlorine into METHENE CHLORIDE CH_2Cl_2; METHENYL CHLORIDE $CHCl_3$ and CARBONIC CHLORIDE CCl_4. **Methyl bromide** CH_3Br. Colorless liquid, boiling at 13° C. **Methyl iodide** CH_3I. Boils at 43° C. Practically: $CH_3OH + IH = OH_2 + CH_3I$. [*b.* **Methene chloride** CH_2Cl_2. **Methene bromide**

CH_2Br_2. **Methene iodide** CH_2I_2. By IH upon methenyl iodide.] *c.* **Chloroform** is TRICHLOR-METHANE or **methenyl chloride** $\mathbf{CHCl_3}$. Colorless, mobile fluid of sp. gr. 1.525 at 0° C. Boils at 63°.5 C. Of pleasant smell, and sweet taste. Little soluble in water; very, in alcohol and ether. By digestion with alcoholic potassium hydroxide, into $2OH_2 + 3ClK +$ POTASSIUM FORMATE $CHO(OK)$. By ammonia, in presence of KOH into $4OH_2 + 3ClK + CNK$. Solvent of I, Br, P, alkaloids, resins, &c. Great anæsthetic. Does not redden litmus or precipitate $NO_2(OAg.)$ Sp. gr. 1.49 at 17° C. [Heated with NO_2OH at 100° C. for some time, into methane-nitro-chloride or CHLOROPICRIN CNO_2Cl_3, a colorless liquid, exciting to tears.] *Prep.* By alkalies upon CHLORAL CCl_3COH. Thus: $CCl_3COH + KOH =$ POTASSIUM FORMATE $CHO(OK) + \mathbf{CHCl_3}$. Also by boiling TRI-CHLORACETIC ACID $\mathbf{CCl_3, COOH}$ with $2HOK = OH_2 + CO(OK)_2 + \mathbf{CHCl_3}$. Also by Cl_2 in presence of hydroxides upon methyl or ethyl alcohol: practically by distilling alcohol, water and chloride of lime. Probably first CHLORAL CCl_3COH, and $5ClH$, and then the chloral by $Ca(OH)_2$ = CALCIUM FORMATE and **chloroform** $\mathbf{CHCl_3}$. **Methenyl bromide** $CHBr_3$. Colorless liquid, odorous, like chloroform, of sp. gr. 2.9.; boils at 152° C. **Methenyl iodide** CHI_3, in yellow tables, with odor of saffron. Milder than iodine. *d.* **Carbon chloride** $\mathbf{CCl_4}$, is a colorless, ethereal fluid which boils at 78° C. Prepared from $CHCl_3$ by $Cl_2 = ClH + \mathbf{CCl_4}$. When digested with $6KOH = 4ClK + 3OH_2 + CO(OK)_2$. **NB.** By nascent $\mathbf{H_2}$ into $\mathbf{CHCl_3}$ or $\mathbf{CH_2Cl_2}$ or $\mathbf{CH_3Cl}$ or $\mathbf{CH_4}$. [NITRO-METHANE $C(NO_2)_4$. TRI-NITRO-METHANE $CH(NO_2)_3$ is nitro-form.]

By digesting the chloride, bromide or iodide of methyl, with potassium or sodium hydroxide, **hydroxyl** is substituted for the halogen, and we obtain the first of an homologous series, the **Alcohols**. The monatomic alcohols are derivatives of the paraffins formed by the substitution of one atom of OH for one atom of H.

METHANE	$C\,H_4$.	METHYL CHLORIDE .	$C\,H_3\,Cl$.
ETHANE	C_2H_6.	ETHYL CHLORIDE .	$C_2H_5\,Cl$.
PROPANE	C_3H_8.	PROPYL CHLORIDE .	$C_3H_7\,Cl$.
BUTANE	C_4H_{10}.	BUTYL CHLORIDE .	$C_4H_9\,Cl$.
PENTANE	C_5H_{12}.	PENTYL CHLORIDE .	$C_5H_{11}Cl$.

METHYL HYDROXIDE . .	$C\,H_3\,OH$.
ETHYL HYDROXIDE . .	$C_2H_5\,OH$.
PROPYL HYDROXIDE . .	$C_3H_7\,OH$.
BUTYL HYDROXIDE . .	$C_4H_9\,OH$.
AMYL HYDROXIDE . .	$C_5H_{11}OH$.

Methyl hydroxide, or **methyl alcohol** $\mathbf{CH_3OH}$, or $\mathbf{HCH_2OH}$. *Woodspirit*, or *pyroxylic spirit*, called **Carbinol** by Kolbe, the

first term of homologous alcohols, in which monad radicles of the form C_nH_{2n+1} replace one atom of H. Where the monad group in an alcohol of the form C_nH_{2n+1} occurs but once, we have **Primary Alcohols**; if the replacement occurs twice, we obtain a **Secondary Alcohol**; but if three units of H in carbinol are replaced by three such groups, we have a **Tertiary Alcohol**.

CARBINOL $\mathbf{CH_3.OH}$ or $\mathbf{HCH_2.OH}$.

PRIMARY CARBINOL.	SECONDARY CARBINOL.
$\mathbf{CH_2}(C_nH_{2n+1}).OH$.	$\mathbf{CH}(C_nH_{2n+1})_2.OH$.

TERTIARY CARBINOL.

$\mathbf{C}(C_nH_{2n+1}.)_3OH$.

Carbinol, or methyl alcohol, is then a colorless liquid, of penetrating odor, inflammable and volatile. Sp. gr. at $0°$ C. 0.8142. Boils at $65°.5$ C. Miscible with water in all proportions, as also with ethyl alcohol and ether. Solvent of resins. Alkalies dissolve and color it brown (URE's test). Burns with paler flame than alcohol. Two stages of oxydation. 1. $CH_3OH + O = OH_2 +$ FORMYL ALDEHYDE $\mathbf{CHOH}$. 2. $CH.OH + O =$ FORMIC ACID $\mathbf{CHO.OH}$. *Prep.* by destructive distillation of wood, neutralizing with $Ca(OH)_2$, redistilling, rectifying over CaO. Uniting with CALCIUM CHLORIDE: $\mathbf{Cl_2Ca,2CH_3OH}$, and decomposing the latter by water. Or from METHYL OXALATE $C_2O_2(OCH_3)_2$ by distillation with sulphuric acid. Also by saponification of oil of Wintergreen, *Gaultheria procumbens* with potassium hydroxide. METHYL SALICYLATE $\mathbf{C_6H_4OHCO.OCH_3} + KOH = C_6H_4.OH.COOK +$ METHYL ALCOHOL $\mathbf{CH_3OH}$. Artificially by Berthelot. 1. $S_2C + 2SH_2 + 4Cu_2 = 4SCu_2 + \mathbf{CH_4}$. Then $CH_4 + Cl_2 = ClH + CH_3Cl$. And $CH_3Cl + KOH = ClK +$ **methyl alcohol** CH_3OH. "Methylated spirit" is a mixture of 90 per cent. of ethyl alcohol with 10 per cent. of methyl alcohol. Methyl alcohol dissolves **Na**, which displaces the **H** of **OH**, and gives a solid SODIUM METHYLATE $\mathbf{CH_3ONa}$. Distilled with METHYL CHLORIDE or CHLORO-METHANE CH_3Cl, into **methylic ether** $\mathbf{CH_3O.CH_3} + ClNa$. With sulphuric acid, methyl alcohol gives **methyl-sulphuric acid** $SO_2(OH)(OCH_3)$, in which the **H** of **OH** can be replaced by metals. **Dimethyl-sulphuric acid** $SO_2(OCH_3)_2$. By distilling, we obtain **methyl-ether** $CH_3.O.CH_3$, a pleasant-smelling gas, fluid at $-23°$ C. **N.B.** In the formation of an ether two molecules of an alcohol part with one molecule of water. Thus: $2CH_3OH = OH_2 + \mathbf{CH_3OCH_3}$. **Methyl-aldehyde HCOH.** Colorless gas. obtained by oxydation of vapor of methyl alcohol over red-hot platinum. Reduces Ag_2O, and becomes oxydized to FORMIC ACID HCOOH. An **aldehyde** (alcohol dehydrogenatus) is derived from an alcohol, by elimination of H_2 in immediate connection with hydroxyl or of the $\mathbf{H_2}$

which belongs to the group **CH_2OH.** The aldehydes are intermediate between alcohols and acids. Thus: $HCH_2OH + O = OH_2 +$ METHYL ALDEHYDE $HCOH$. A polymeric modification of this gaseous aldehyde exists in a solid state; probably $H_3C_3O_3H_3$. **Formic acid $HCO.OH$.** Colorless liquid, of very acid and piquant odor. Boils at 99° C. and is crystalline at 8°.5 C. It is miscible with water in all proportions, and is an energetic monobasic acid, the first of an homologous series—the FATTY ACIDS. It is contained in red ants, in the sting of nettles, wasps, and bees, &c. Prepared by Berthelot: $CO + HOK =$ **$HCOOK$.** Most easily by heating at 100° C. equal parts of glycerin and oxalic acid: the latter $(CO.OH)_2 = CO_2 +$ **$HCOOH$.** Heated with $SO_2(OH)_2 = OH_2 + CO$. With Ag_2O into $Ag_2 + OH_2 + CO_2$. FORMATES. AMMONIUM FORMATE $HCO.OH_4N$, crystallizes in prisms: heated into: $2OH_2 +$ HYDROGEN CYANIDE **CNH.** COPPER FORMATE $(CHO)_2O_2Cu,4OH_2$, and LEAD FORMATE $(CHO)_2O_2Pb$, are most characteristic. By distilling $HCO.ONa + HONa = CO(ONa)_2 + H_2$. But, by distilling alone: $HCOONa + HCOONa = CO(ONa)_2 + HCOH$. METHYL FORMATE $HCO.OCH_3$ is a colorless liquid, which boils at 33.°4 C. Theoretically, the **anhydride of formic acid** is obtained from two molecules, by the loss of one molecule of water. Thus: $HCOOH + HCOOH = OH_2 +$ **HCO–O–HCO.** **Formamide** $(HCO)H_2N$ is a colorless liquid, boiling at 194°.

Carbonic anhydride CO_2. Hypothetical CARBONIC ACID **$CO(OH)_2$.** In CHLORO-CARBONIC ACID $COCl_2$, **Cl_2** substitutes $(OH)_2$ in carbonic acid, or one atom of **O** in CO_2. Formed from $CO + Cl_2$ in sunlight. Called phosgene.

Carbonic sulphide $SCS = CS_2$ is the analogue of CO_2. P. 12. A colorless liquid of sp. gr. 1.27. Boils at 46° C. $CS_2 + SK_2 = CS(SK)_2$. By nascent H_2 into METHYL-SULPHALDEHYDE **$HCSH$:** $CS_2 + 2H_2 = S_2H +$ **$HCSH$.** [Also **$CS(SH)_2$. CSSHOH. COSHOH.**] METHYL-SULPHYDRATE **$CH_3.SH$**, is METHYL MERCAPTAN. Colorless, mal-odorous liquid, boiling at 21° C. *Prep.* by action of **HSK** upon **CH_3Cl** $= ClK +$ **CH_3SH.** METHYL SULPHIDE CH_3SCH_3 is the analogue of methyl-ether. It boils at 41° C., and is prepared by using KSK with $2CH_3Cl$. [**Carbonic oxy-sulphide** COS colorless gas. **Carbonyl sulpho-chloride ClCSCl**, by Cl_2 on CS_2. Thus: **SCS** $+ 2Cl_2 = ClSCl +$ **ClCSCl.**] **Hydrogen cyanide CNH** may be regarded as methane in which nitrogen substitutes three atoms of hydrogen; hence *azomethane*. It may also be called a **nitrile, a compound of nitrogen with a trivalent radicle** METHENYL. One common method of obtaining a nitrile is by de-hydrating the ammonium salt of the fatty acid by P_2O_5. Thus; $HCOOH_4N - 2OH_2 = CH'''N$ or CNH. And the converse: $CNH + 2OH_2 = HCOOH_4N$. **Cyanogen** C_2N_2, or **dicyanogen,** as it is represented molecularly, is a gas, colorless, of

pungent odor resembling prussic acid. Sp. gr. 1.80. Water absorbs four to five vols. Under pressure of four atmospheres into a colorless liquid which boils at − 21° C., and solidifies at − 34° C. Burns with rose-colored flame. Passed into strong ClH, it takes up two of OH_2 and becomes OXAMIDE $C_2O_2(NH_2)_2$. And, in water, **Cyanogen** by 4**OH_2** into AMMONIUM OXALATE $(CO.OH_4N)_2$. Passed into sol. of HOK into CYANIDE and CYANATE: $2HOK + C_2N_2 = \mathbf{CNK} + \mathbf{CNOK} + OH_2$. *Prep.* *a.* By heating MERCURIC CYANIDE = Hg + $\mathbf{C_2N_2}$. A portion, into brown solid: PARACYANOGEN $(C_3N_3)_2$, a polymeric modification of C_2N_2. *b.* By passing air over a red-hot mixture of potassium carbonate and charcoal: $CO(OK)_2 + 4C + N_2 = 2\mathbf{CNK} + 3CO$. **Cyanides.** Cyanogen is a monad radicle. Unites with H. **Hydrogen cyanide** CNH is commonly called *prussic acid.* 1782 by Scheele. Anhydrous acid is a colorless, volatile liquid, of sp. gr. 0.7058 at 5° C., boiling at 26°.5 C. Feebly acid. Odor as of peach-blossoms. Very poisonous. When inhaled even in small quantities, produces headache, giddiness, &c. Antidotes: chlorine, water, ammonia, affusion of cold water. Cannot be preserved in the light; deposits paracyanogen, evolves ammonia, and ammonium formate always in solution. Used as medicine. *Prep.* Anhydrous acid. $CNHgCN + SH_2 = SHg + 2CNH$. Of *ordinary.* *a.* From bitter almonds, by the action of moist synaptase upon AMYGDALIN $C_{20}H_{27}NO_{11},3OH_2$. 17 grains of amygdalin dissolved in 1 oz. of sweet almonds-emulsion would yield 1 grain of CNH. The ordinary acid of the Pharmacopœia contains 2 per cent. of CNH. Now 100 grains of tartaric acid dissolved in 2 oz. of water, to which 44 grains of CNK have been added, will, when decanted, yield an acid of desired strength. From CNK by dilute $SO_2(OH)_2, 2OH_2 = SO_2OH.OK + CNH + 2OH_2$. Also from potassium ferrocyanide. Tests: volatility, formation of silver cyanide, of Prussian blue and of ferric sulphocyanide. POTASSIUM CYANIDE CNK. In deliquescent, colorless cubes. Alkaline reaction, as in water into hydrocyanide of potash: emits CNH. Soluble in alcohol. Fuses at red-heat. K_2 burns when heated in C_2N_2 into 2CNK. Most easily by heating potassium ferrocyanide with $CO(OK)_2$ and carbon $= 3CO + Fe + 6\mathbf{CNK}$. Potassium cyanide dissolves iron. In presence of air: $6CNK + Fe + OH_2 + O = 2HOK + C_6N_6FeK_4$. In absence of air: $6CNK + Fe + 2OH_2 = 2HOK + H_2 + C_6N_6FeK_4$.—$18CNK + 3Cl_2Fe + 2Cl_6Fe_2 = 18ClK + C_{18}N_{18}Fe_7$. AMMONIUM CYANIDE CNH_4N, in colorless cubes: volatile. Very poisonous. By subliming mixt $CNK + ClH_4N$. SILVER CYANIDE CNAg, white, amorphous, soluble in strong NO_2OH, H_3N and in CNK. Soluble to CNK,CNAg, a double salt. To estimate CNH, add to measured quantity HOK, and then, by a burette, solution of NO_2OAg until permanent precipi-

tate appears. As soon as *half* the quantity of CNH is changed into CNAg, one additional drop precipitates white CNAg, *permanent.* 170 parts of NO_2OAg correspond to 130 parts of CNK and 54 parts of CNH. MERCURIC CYANIDE C_2N_2Hg in rectangular prisms. 2CNH readily dissolve precipitated HgO $= OH_2 + C_2N_2Hg$. *Prep.* $C_6N_6FeK_4 + 3SO_4Hg = 2SO_4K_2 + SO_4Fe + 3\mathbf{C_2N_2Hg}$. AUROUS CYANIDE CNAu, lemon-yellow powder, not decomposed even by boiling acids. CNK,CNAu much used in electro-gilding. NICKEL CYANIDE C_2N_2Ni, apple-green, readily soluble to $2CNK,C_2N_2Ni$, re-precipitated by ClH. COBALT CYANIDE C_2N_2Co is brownish-red, easily soluble in CNK. But, when slightly acidulated and boiled, H_2 is given off and potassium cobalticyanide is obtained, *not* precipitated by ClH : used to separate Ni from Co. TITANIUM NITRO-CYANIDE $C_2N_2Ti,3N_3Ti_2$.

Ferrocyanides. **Ferrocyanogen** is tetrabasic. POTASSIUM FERROCYANIDE $\mathbf{C_6N_6FeK_4.3OH_2}$. Yellow prussiate of potash. In large lemon-yellow crystals, derived from an octahedron with a square base. Soluble in 4 of cold, and 2 of boiling water. Insoluble in alcohol. Not poisonous; purgative. Source of **CNH**: $2C_6N_6FeK_4 + 6(SO_4H_2,2OH_2) + aq. = 6SO_2(OH)(OK) + 12OH_2 + aq. + 6\mathbf{CNH} + C_6N_6Fe_2K_2$, known as EVERITT'S SALT. Also of **CNK** (see above). $C_6N_6FeK_4$ at red-heat $= 4CNK + C_2Fe + N_2$. With SO_4H_2 yields **CO**. Thus: $C_6N_6FeK_4 + 6(SO_4H_2,OH_2) = 2SO_2(OK)_2 + SO_2(O_2Fe) + 3[SO_2(OH_4N)_2] + 6\mathbf{CO}$. In this last reaction $CNH + OH_2 = CO + H_3N$. *Prep. of the salt.* From dry animal matters, as horn, hoofs, &c., at a red-heat, in contact with $CO(OK)_2$ and iron-filings. The **CNK** produced, reacts when water is added upon the iron (see above) and upon ferrous sulphide: $6CNK + SFe = SK_2 + \mathbf{C_6N_6FeK_4}$. Largely used in making "Prussian blue," and is a delicate test for a ferric salt: $2Cl_6Fe_2 + 3C_6N_6FeK_4 = 12ClK + 2Fe_2,3FeC_6N_6$. With a ferrous salt, a white precipitate $C_6N_6Fe_2K_2$, turning blue on exposure to air. Thus: $C_6N_6FeK_4 + SO_4Fe = SO_4K_2 + C_6N_6Fe_2K_2$. or Everitt's salt. By air: $6C_6N_6Fe_2K_2 + 3O = Fe_2O_3 + 3C_6N_6FeK_4 + 2Fe_2Cy_6,3FeC_2N_2$. CUPRIC FERROCYANIDE $C_6N_6FeCu_2$, red-brown : a test for cupric salts. HYDROGEN FERROCYANIDE $C_6N_6FeH_4 = CfyH_4$. White scales, insoluble in ether. Powerfully acid solution. very soluble in water, and blues on exposure. Ag_4, Pb_2, Zn_2, Mn_2 and Bi ferrocyanides are white and insoluble. **Ferricyanides.** Ferricyanogen is hexabasic. POTASSIUM FERRICYANIDE $C_{12}N_{12}Fe_2K_6$ is "red prussiate of potash." Ruby-red prisms, freely soluble in water. By passing Cl_2 through sols. of $2C_6N_6FeK_4 = 2ClK + C_{12}N_{12}Fe_2K_6$. An oxydizing agent in alkaline solutions, thus : $4HOK + 2C_{12}N_{12}Fe_2K_6 = O_2 + 2OH_2 + 4C_6N_6FeK_4$. A test for ferrous : $3SO_4Fe + C_{12}N_{12}Fe_2K_6 = 3SO_4K_2 + C_{12}N_{12}Fe_2Fe_3$,

"Turnbull's blue." No precipitate with ferric salts, only browning. HYDROGEN FERRICYANIDE $C_{12}N_{12}Fe_2H_6$ in red, unstable crystals, by decomposing lead ferricyanide by SH_2 and evaporation. [**Nitro-prussides.** SODIUM NITROPRUSSIDE $C_5N_5NOFeNa_2$, ruby-red crystals. By digesting $C_5N_5Fe_2Na$ with NOONa + OH_2 = $Fe(OH)_2$ + $C_5N_5FeNONa_2$. Generally by action of nitric acid upon sodium ferrocyanide. Test for alkaline sulphides: gives purple color. HYDROGEN NITRO-PRUSSIDE in crystals.] **Cobalticyanides.** POTASSIUM COBALTICYANIDE $(CN)_{12}Co_2K_6$, in yellowish, flattened prisms, isomorphous with $C_{12}N_{12}Fe_2K_6$. **Chromicyanides.** POTASSIUM CHROMICYANIDE $(CN)_{12}Cr_2K_6$, brownish-red prisms. **Potassium manganocyanide** $(CN)_6MnK_4,3OH_2$, deep-blue square tables. POTASSIUM MANGANICYANIDE $(CN)_{12}Mn_2K_6$ deep-red, rhombic prisms.

Cyanogen and **Chlorine.** CYANOGEN CHLORIDE CNCl, a liquid boiling at 12°.6 C. By action of Cl_2 upon CNH. Polymeric modification $C_3N_3Cl_3$, a solid, by passing Cl_2 into a solution of CNH in ether. **CNBr**, in needles. CNI, in needles. By action of I_2 upon C_2N_2Hg. CYANAMIDE CNH_2N from CNCl + $2H_3N$ = ClH_4N + CNH_2N. **Methyl cyanide** $\mathbf{H_3CCN}$ = $(C_2H_3)N$ is *ethenyl nitrile.* Also called aceto-nitrile, because it can be prepared from acetamide by loss of OH_2. $C_2H_3OH_2N - OH_2 = C_2H_3N$. By distilling CNK with $SO_4CH_3K = SO_4K_2$ + $\mathbf{H_3CCN}$. Boils at 77° C. By heating with KOH (absorption of $2OH_2$), into $\mathbf{H_3N}$ and salt of corresponding **fatty acid.** As CNH + $2OH_2$ = H_3N + HCOOH, so H_3CCN + $2OH_2$ = H_3N + ACETIC ACID. CH_3COOH. **Methyl isocyanide** H_3CNC, boils at 59° C., of very repulsive odor. From CH_3I with CNAg. In isocyanides, C directly united with pentad N. When isocyanide treated with HOK, an **amine** produced (an alcoholic ammonia) and **formic acid.** Thus: H_3CNC + $2OH_2$ = METHYLAMINE $N(CH_3)H_2$ + HCOOH.

Cyanic acid CNOH, limpid, colorless liquid, pungent like acetic acid. By OH_2 into H_3N and CO_2, which unite to $CO(OH)(OH_4N)$, and cannot be separated by acids from cyanates. Changes spontaneously into solid CYAMELID (isomeric). *Prep.* of **CNOH**: distilling the polymeric modification CYANURIC ACID $(CN)_3(OH)_3$ = 3**CNOH**. **Cyanates**: by oxydation of cyanides. POTASSIUM CYANATE **CNOK**, crystallizes from alcohol in thin, transparent plates. *Prep.* CNK + PbO = Pb + CNOK. Slowly by moisture into H_3N and CO(OH)(OK). AMMONIUM CYANATE $CNOH_4N$. By mixing vapor of CNOH with H_3N, a white crystalline solid. With ClH, evolves CO_2, and with HOK, ammonia. But, *if heated,* into **urea** $CO(H_2N)_2$ which is metameric with cyanate of ammonium. [**Cyanuric acid** $\mathbf{(CN)_3(OH)_3,2OH_2}$ = $C_3N_3O_3H_3,2OH_2$, colorless, oblique-rhombic prisms. Tri-basic. Little soluble. Very stable. By passing dry Cl_2 over melted urea $CO(H_2N)_2$

and removing H_4NCl by water. $6CO(H_2N)_2 + 3Cl_2 = 2ClH + N_2 + 4H_4NCl + 2C_3N_3O_3H_3$. By heat into cyanic acid. **Fulminic acid** $C_2N_2O_2H_2$ not known in free state. Dibasic. SILVER FULMINATE $C_2N_2O_2Ag_2$, white crystalline plates, soluble in 36 of boiling water. Explodes violently when heated or rubbed. $2NO_2OAg + N_2O_3 + C_2H_5OH = 2OH_2 + 2NO_2OH + C_2N_2O_2Ag_2$. MERCURIC FULMINATE $C_2N_2O_2Hg$ resembles the silver salt. In percussion-caps. **Fulminuric acid** $C_3N_3H_2O_2OH$ is mono-basic. Also, isocyanuric acid.]

Urea $CON_2H_4 = CO(H_2N)_2$, the most abundant constituent of the urine, was artificially produced by Woehler in 1828 from ammonium cyanate $CNOH_4N$ by heating to 100° C. In the urine of man it varies, but may be said to average 1.4 per cent. It crystallizes in long striated needles, very soluble in water and in alcohol. By $2NOOH = CO_2 + 2N_2 + 3OH_2$. By CHLORINE: $CON_2H_4 + OH_2 + 3Cl_2 = 6HCl + CO_2 + N_2$. Heated to 120° C., it fuses and decomposes into AMMELINE $C_3N_3OH(H_2N)_2$ and at 150° C. into BIURET $C_2H_5N_3O_2$ [and biuret (3) into $3H_3N + 2(CN)_3(OH)_3$.] Urea unites with NO_2OH, in shiny scales or rhombic prisms to NITRATE $CO(H_2N)_2,NO_2OH$ very little soluble. Obtained by evaporating urine to syrup, and after filtration adding its own bulk of nitric acid. Urea from this nitrate by COO_2Ba, evaporation and solution in boiling alcohol, in which barium nitrate insoluble. OXALATE $(COOH)_2 2CON_2H_4$ in transparent prisms. Urea from this oxalate by Calcium carbonate and solution in water. With mercuric nitrate urea forms three compounds, and unites also with HgO and other bases. Heated with OH_2 in closed tubes at 100° C., into carbonate of ammonium. It is the **Diamide** of carbonic anhydride, and contains the elements of ammonium carbonate *minus* $2OH_2$. Isomeric with CARBAMIDE, but not identical, as when heated with alkaline solution of potassium permanganate it gives off its **Nitrogen** as such, whereas carbamide has its N oxydized to nitric acid. Artificially prepared from CHLORO-CARBONIC ACID $COCl_2 + 2H_3N = 2ClH +$ UREA. Also from ETHYL CARBONATE $CO(OC_2H_5)_2 + 2H_3N = 2C_2H_5OH +$ UREA. [Urea containing alcohol radicles. ETHYL-UREA $COH_3(C_2H_5)N_2$. DI-ETHYL UREA $COH_2(C_2H_5)_2N_2$. METHYL-UREA $COH_3(CH_3)N_2$, &c., &c.]

Sulphocyanate of potassium CNSK, corresponds to the cyanate CNOK. Deliquescent, striated prisms. **Deep-red color** with Cl_6Fe_2, bleached by Cl_2Hg, and evolving SH_2 with Zn and acid. Easily prepared by melting CNK with sulphur. Also by calcining S with $(CN)_6FeK_4$ and $CO(OK)_2$. **CNSNa** in the saliva. HYDROGEN SULPHOCYANIDE CNSH, an oily liquid resembling acetic acid, easily resolving itself into CNH and HYDROGEN PERSULPHOCYANIDE $C_2N_2S(SH)_2$. ISOSULPHOCYANIDE OF POTASSIUM **NCSK**, from the latter compound by alcoholic HOK.

Browns with Cl_6Fe_2. By fusion into CNSK. AMMONIUM SULPHOCYANATE $CNS(H_4N)$ in colorless, deliquescent tables. At 140° C., in part at least into **Sulphur-urea** $CS(H_2N)_2$, or urea in which S takes the place of O in carbonyl CO.—**Allyl iso-sulphocyanate** $NCS(C_3H_5)$ pungent, volatile "*oil of mustard.*" By action of myrosin and water upon myronic acid in seeds of black mustard. Burning taste. Blisters the skin. Boils at 148° C.—By passing Chlorine into CNSK, yellow, insoluble PERSULPHOCYANOGEN $C_3N_3H.S_3$ is produced. Insoluble in water, alcohol and ether. When heated, into HYDROMELLONE $C_6N_9H_3$. Thus $6C_3N_3HS_3 = 6CS_2 + 3S_2 + 2C_6N_9H_3$.

Amines. Derivates of H_3N by substitution of alcohol-radicles for Hydrogen. **Monamines,** from one molecule of H_3N by monatomic radicles; **Diamines,** from two molecules of H_3N by diatomic radicles; **Triamines,** from three molecules, by triatomic radicles. The nitrogen may be substituted by Phosphorus, Stibium, Arsenicum. Monamines may be primary, secondary or tertiary, according to removal of one atom, two, or three atoms of hydrogen. The amines resemble ammonia in properties. Thus: tri-methylamine unites with methyl iodide to TETRAMETHYLAMMONIUM IODIDE $N(CH_3)_4I$. **Methylamine** NH_2CH_3. **Dimethylamine** $NH(CH_3)_2$. **Tri-methylamine** $N(CH_3)_3$. Is contained in herring-brine. **Tetramethyl-ammonium hydrate** $N(CH_3)_4OH$. When heated into trimethylamine and methylic alcohol: $N(CH_3)_3 + CH_3OH$.—**Tri-methyl phosphine** $P(CH_3)_3$. Colorless oily liquid. With methyl iodide into TETRAMETHYL PHOSPHONIUM IODIDE $P(CH_3)_4I$, and this by silver hydrate into TETRAMETHYL PHOSPHONIUM HYDRATE $P(CH_3)_4OH$.—**Tri-methylarsine** $As(CH_3)_3$. Unites with CH_3I to TETRAMETHYL ARSONIUM IODIDE $As(CH_3)_4I$, from which AgOH separates the hydrate. **Arsen-dimethyl** $As_2(CH_3)_4$ is "*cacodyl.*" Spontaneously inflammable. "Alkarsin." Colorless, transparent liquid, of horrible odor, intensely poisonous. By heating an acetate with arsenious anhydride. Unites with Cl_2 and splits into two. CACODYL CHLORIDE $As(CH_3)_2Cl$, colorless, fuming, poisonous liquid; boils above 100° C. With Zn gives pure cacodyl. $As(CH_3)_2I$. $As(CH_3)_2CN$. By slow oxydation cacodyl into **Oxide of cacodyl** $As_2(CH_3)_4O$. By further oxydation into **Cacodyl dioxide** $As_2(CH_3)_4O_2$. Yet complete oxydation into **Cacodylic acid** $As(CH_3)_2OOH$.—**Trimethyl stibine** $Sb(CH_3)_3$. Also: $Sb(CH_3)_4I$. And $Sb(CH_3)_4OH$.

Metallic methides. ZINC METHYL OF ZINC METHIDE. $Zn(CH_3)_2$. By heating methyl iodide with Zinc under pressure. Colorless, spontaneously inflammable gas, decomposed by water into ZINC-HYDROXIDE $Zn(OH)_2$ and METHANE CH_4. STANNOUS METHIDE $Sn(CH_3)_2$. STANNIC METHIDE $Sn(CH_3)_4$. ALUMINUM METHIDE $Al_2(CH_3)_6$. MERCURIC METHIDE $Hg(CH_3)_2$. Very

poisonous liquid. LEAD METHIDE $Pb(CH_3)_4$. SILICON METHIDE $Si(CH_3)_4$.

II. Di-carbon group C_2. Ethane C_2H_6 and derivatives.

By substituting methyl for hydrogen in methane, we obtain dimethyl or ethane. Thus $CH_3CH_3 = C_2H_6$.

Ethane, the second of the paraffin group, C_2H_6 differs by CH_2 from methane, and is the second in this homologous series. $(C_2H_5)_2Zn + 2OH_2 = Zn(OH)_2 + 2C_2H_6$. Also by electrolysis of acetic acid: $2CH_3COOH = H_2 + 2CO_2 + CH_3CH_3$. Colorless gas, burning with pale flame. By action of chlorine into **chlorethane or ethyl chloride** C_2H_5Cl and ClH. **Ethene** CH_2CH_2 or C_2H_4, ETHYLENE or OLEFIANT GAS. Colorless gas, inflammable with bright flame, burning into $2CO + 2OH_2$. Dyad radicle. Unites directly with Cl_2, Br_2, I_2. Thus $CH_2ClCH_2Cl = C_2H_4Cl_2$ is Dutch Liquid. In presence of nascent H_2 into ethane again. ETHENE C_2H_4 is prepared by abstraction of OH_2 from ethylic alcohol C_2H_5OH. It is also called an *olefine*. Also made by passing the chloride of the alcohol radicle over CaO. Thus: $2C_2H_5Cl + CaO = Cl_2Ca + OH_2 + 2C_2H_4$. Also from ethine C_2H_2 by H_2 nascent $= C_2H_4$. **Acetylene or ethine** $CHCH = C_2H_2$, colorless gas of unpleasant odor, burning with sooty flame. Often formed in incomplete combustion of CH_4 and of C_2H_4. Thus: $4CH_4 + 3O_2 = 6OH_2 + 2C_2H_2$. Again: $2C_2H_4 + O_2 = 2OH_2 + 2C_2H_2$. Formed from its elements by heating Carbon points whilst glowing in hydrogen. Also by heating $C_2H_4Br_2$ with $2HOK = 2BrK + 2OH_2 + C_2H_2$. Ethine by nascent hydrogen into ethene. It is absorbed by ammoniacal cuprous chloride and silver nitrate: C_4Cu_4,OH_2. C_2Ag_2,OH_2.

Ethyl hydroxide or Methyl carbinol. $C_2H_5OH = C\{CH_3H_2OH = CH_3,CH_2OH$. As "absolute alcohol," colorless, volatile, of strong spirituous odor. Inflammable; burning to $2CO_2$ and $3H_2O$. Sp. gr. 0.8095 at 0° C., and 0.794 at 15°.5 C. Never frozen. Viscid at −110° C. Boils at 78°.5 C. Great affinity for water. A solvent of gases, deliquescent salts, but not of $CO(OK)_2$, of HOK, HONa, of I (tincture), Br, of resins (varnishes), essential oils (various Eaux de) alkaloids, &c. Fats and fixed oils, except castor-oil, but little soluble. Forms *alcoates:* in them it takes the place of water of crystallization as in $Cl_2Ca,4C_2H_5OH$. "Proof-spirit" contains 49.24 per cent. of alcohol by weight. Practically every additional 0.5 per cent. of absolute alcohol, to proof-spirit, is one degree above proof. Absolute alcohol is made by long digestion of rectified spirit of wine upon CaO, and distillation. Can be made from its elements: *a.* From $C_2 + H_2$ at white-heat $= C_2H_2$. *b.* ETHINE C_2H_2 by nascent H_2, into ETHENE C_2H_4. *c.* ETHENE C_2H_4 with

$SO_2(OH)_2$ into ETHYL SULPHURIC ACID $SO_2OH(OC_2H_5)$. *d.* By $2HOK$ into $SO_2(OK)_2 + OH_2 +$ **CH_3,CH_2OH**. Or by distillation with water, into sulphuric acid and ethyl alcohol. VINOUS FERMENTATION. The ferment is probably a fungus *Torula cerevisiæ* and *Penicillium glaucum*, which lives upon the albumen contained in juice, say of grape, and induces a change which brings about the alcoholic fermentation of the GLUCOSE $C_6H_{12}O_6$ into $2CO_2 +$ **$2CH_3.CH_2OH$**. Temperature of 21°.2 C. most favorable to fermentation. Port contains from 15 to 17 per cent. of alcohol calculated as absolute; Sherry, 14 to 16 per cent.; Madeira, 14 to 17; Amontillado, 12.6; Claret, 8 to 9; Rhine wines from 7 to 10 per cent. Claret, Burgundy, and Rhine wines contain but little sugar; sherry less than port. CREAM OF TARTAR $C_2H_2(OH)_2(COOH)(COOK)$ in all grape-vines: least in old wines. Alcohol, as genuine wine, rouses sluggish digestions, limits the metamorphosis of food, gives temporary strength to nervous system, carries off the effects of chills, and prevents the absorption of bad odors. When diet is insufficient, it arrests the progress of decay till nature can again assert the power of the stomach to take food.

Ethers of ethylic. CHLORETHANE $C_2H_5Cl = CH_3CH_2Cl$. Colorless, volatile liquid, of sp. gr. 0.921, boils at 12°. 5C. By Cl_2 in excess, into C_2Cl_6 ultimately. With aqueous $HOK = ClK + C_2H_5OH$. With alcoholic HOK into $ClK + C_2H_5OC_2H_5$. Also with $C_2H_5OK + C_2H_5Cl = ClK + C_2H_5OC_2H_5$. With soda-lime into $2ClNa + OH_2 + C_2H_4$. *Prep.* from ClH upon $C_2H_5OH = OH_2 + C_2H_5Cl$. BROMETHANE C_2H_5Br. Volatile liquid, heavier than water. IODETHANE C_2H_5I or ETHYL IODIDE. Colorless liquid, of ethereal odor, of sp. gr. 1.92 and boils at 72° C. Very important. By distilling 70 parts of alcohol, 100 parts of iodine and 5 parts of phosphorus. Practically $PI_3 + 3C_2H_5OH = P(OH)_3 + 3C_2H_5I$. CYANETHANE or ETHYL CYANIDE **CNC_2H_5**, is PROPENYL NITRILE C_3H_5N. Boils at 82° C. By heating with $KOH + 2OH_2 = H_3N +$ PROPIONIC ACID C_2H_5COOH. ETHYL ISO-CYANIDE **NCC_2H_5** by $2OH_2 =$ ETHYLAMINE $(C_2H_5)'H_2N +$ FORMIC ACID $HCOOH$. ETHYL OXIDE or ETHYL ETHER **$C_2H_5OC_2H_5$** $= C_4H_{10}O$ is common "ether." Colorless, transparent, fragrant liquid, very mobile. Sp. gr. 0.72. Boils at 35°.6 C. Very combustible: one molecule of the vapor requires six molecules of O. Miscible with alcohol in all proportions. Ten parts of water take up one part of ether. Solvent of oils and fats, and of some salts and alkaloids. Vapor very heavy; 2.586 that of air. By long action of Cl_2 in sunshine into $C_4Cl_{10}O$.

When Na introduced into ethyl alcohol, SODIUM ETHYLATE C_2H_5ONa is produced and H. POTASSIUM ETHYLATE C_2H_5OK, by same means. Thus: $2C_2H_5OH + K_2 = 2C_2H_5OK + H_2$. Now: $C_2H_5OK + C_2H_5Cl = ClK +$ **$C_2H_5OC_2H_5$**. (*See* ethyl-sulphuric

acid.) ETHYL SULPHIDE $C_2H_5SC_2H_5$, colorless oily liquid of pungent alliaceous odor, of sp. gr. 0.825, and boils at 72° C. Very inflammable. ETHYL HYDROGEN SULPHIDE C_2H_5SH. MERCAPTAN. Colorless, limpid fluid of sp. gr. 0.842. Boils at 36° C. (*See* methyl, p. 85.) ETHYL NITRATE $NO_2OC_2H_5$. Sp. gr. 1.112. Insoluble in water. Boils at 85° C. Urea employed to prevent the formation of nitrite. (*See* UREA, p. 89.) ETHYL NITRITE $NOOC_2H_5$. Pale-yellow liquid, with odor of apples. Sp. gr. 0.947: boils at 16°.6 C. A solution in alcohol mixed with aldehyde, constitutes *Spiritus etheris nitrosi*. ETHYL FORMATE $HCOOC_2H_5$. Liquid of faint odor as of CNH. Sp. gr. 0.915. Boils at 53° C. ETHYL SULPHATE $SO_2(OC_2H_5)_2$. Syrup which cannot be distilled. ETHYL HYDROGEN SULPHATE or *sulphovinic acid* $SO_2OHOC_2H_5$. Sour, syrupy liquid, in which sulphuric acid not recognizable by ordinary tests. By mixing rectified spirit with twice its weight of sulphuric acid. CALCIUM ETHYL-SULPHATE. $SO_2(OC_2H_5)_2, SO_2(O_2Ca), 2OH_2$ colorless, transparent crystals. Distilled with HSK, gives mercaptan. POTASSIUM ETHYL SULPHATE $SO_2(OC_2H_5)(OK)$ by $CO(OK)_2$ from former salt. When a thin stream of C_2H_5OH is poured into boiling **Ethyl hydrogen sulphate, at a temperature of about 149° C., continuous etherification** is effected. Thus: $SO_2(OH)(OC_2H_5) + C_2H_5OH = SO_2(OH)_2 + C_2H_5OC_2H_5$. Then: $SO_2(OH)_2 + C_2H_5OH = OH_2 + SO_2(OH)(OC_2H_5)$. ETHYL-DIHYDROXYL PHOSPHATE $PO(OH)_2OC_2H_5$. ETHYL BORATE $BO(OC_2H_5)$. ETHYL SILICATE $Si(OC_2H_5)_4$. From $Cl_4Si + 4C_2H_5OH = 4ClH + Si(OC_2H_5)_4$. ETHYL CARBONATE $CO(OC_2H_5)_2$. Aromatic liquid; boils at 125° C. $CO(OAg)_2 + 2C_2H_5I = 2IAg + CO(OC_2H_5)_2$. ETHYL HYDROXYL CARBONATE $CO(OH)(OC_2H_5)$. Crystalline. By passing dry CO_2 into solution of HOK in absolute alcohol. ETHYL SULPHOCARBONATES. $CO(OH)SC_2H_5$. $CO_2S(C_2H_5)_2$.

Double ethers. METHYL-ETHYL ETHER $CH_3OC_2H_5$. Boils at 11° C. Thus: $CH_3OK + C_2H_5I = IK + CH_3(OC_2H_5)$.

Ethyl aldehyde $H_3C(COH) = C_2H_4O$. Colorless, mobile, ethereal liquid. Sp. gr. 0.8. Boils at 21° C. Inflammable. Reducing agent. Thus: $Ag_2O + H_3C(COH) = H_3C(COOH) + Ag_2$. With alkaline acid sulphites, crystalline compounds, as $SO(OH)(ONa).C_2H_4O$. By nascent H_2, into respective alcohols. H_3N in ethereal solution of aldehyde, gives crystalline ALDEHYDE-AMMONIA $H_3CCHOHH_2N = C_2H_4(H_3N)O$. Heated with $HOK = H_2 +$ POTASSIUM ACETATE $C_2H_3O(OK)$. By $Cl_5P = POCl_3 +$ chloraldehyde $CH_3.CHCl_2$. By $Cl_2 = ClH +$ acetyl chloride $C_2H_3O.Cl$. Fused with $HOK = H_2 + C_2H_3O(OK)$. Several polymeric modifications, as PARALDEHYDE, and METALDEHYDE. ALDOL is another. *Prep.* distilling $C_2H_5(OH)$ with $SO_2(OH)_2$ and $CrO_3, CrO_2(OK)_2$: O_2 oxydizes two mols. of alcohol by removing $2OH_2$. Also, by distilling sodium acetate

with sodium formate: into $CO(ONa)_2$ + $\mathbf{H_3CCOH}$. **Acetal** $C_2H_4O.O(C_2H_5)_2 = C_6H_{14}O_2$, is aldehyde-ether. Colorless, ethereal liquid of sp. gr. 0.821 at 22°.2 C., and boils at 140° C. By platinum black into aldehyde, and then, acetic acid. From $C_2H_4O.C_2H_5Cl$ by C_2H_5ONa = $ClNa$ + **Acetal**. **Chloral** or **Chloraldehyde** CCl_3COH = $\mathbf{C_2HCl_3O}$. Thin, oily, colorless fluid, of penetrating odor. Sp. gr. 1.502. Boils at 94° C. Freely soluble in water, alcohol, and ether. With a small quantity of water, it forms **Chloralhydrate** C_2HCl_3O,OH_2. Much used in medicine. Unites also with ethylalcohol. Heated with alkalies into CHLOROFORM $CHCl_3$ (p. 83) and FORMATE of the metal. Behaves like an aldehyde. By O into TRI-CHLORACETIC ACID $CCl_3,COOH$. *Prep.* by action of $4Cl_2$ upon ethyl-alcohol, or of $3Cl_2$ upon aldehyde. Thus: $CH_3CH_2OH + 4Cl_2 = 5ClH +$ $\mathbf{CCl_3,COH}$. BROMAL CBr_3,COH. Boils at 172° C.

Acetic acid $\mathbf{H_3C.COOH}$ = CH_3COOH or $\mathbf{C_2H_4O_2}$. The second of the fatty acids, derived from the paraffin series of hydrocarbons. Monobasic. Is found in the juices of many plants as acetate. Glacial acetic acid, in lustrous plates, fusing at 17° C. Sp. gr. of liquid 1.055. Boils at 118° C. Miscible with water, alcohol and ether. Five per cent. or less in vinegar. "Pyroligneous acid" by destructive distillation of wood. Mainly prepared by oxydation of alcohol. $H_3CCH_2OH + O_2 = OH_2 +$ $\mathbf{H_3CCOOH}$. Phosphoric chloride changes acetic acid into **Acetyl chloride** C_2H_3OCl. Thus: $C_2H_3O.OH + PCl_5 = POCl_3 + ClH$ $+ C_2H_3OCl$. By passing the vapor of acetic acid through a red-hot tube, we obtain **Acetone** CH_3COCH_3. **Acetates. Potassium acetate** $C_2H_3O.OK$, foliated, deliquescent. Used in medicine as a diuretic. **Sodium acetate** $C_2H_3O.ONa,3OH_2$ in oblique rhombic prisms, very soluble in water. Used in making the acid with SO_4H_2. Also for METHANE CH_4. Thus: $CH_3COONa + HONa$ $= CO(ONa)_2 + \mathbf{CH_4}$. **Ammonium acetate** CH_3COOH_4N, diaphoretic. Important. Heated with P_2O_5, loses $2OH_2$, into **Ethenyl nitrile** $(C_2H_3)N$ or aceto-nitrile. **Methyl acetate** $CH_3COO(CH_3)$, in wood spirit. Colorless, fragrant liquid. Boils at 55° C. **Ethyl acetate** $CH_3CO(OC_2H_5)$, fragrant limpid fluid, of sp. gr. 0.89, and boils at 73°.8 C. By distilling sodium acetate with ethyl alcohol and sulphuric acid. Thus: $CH_3CH_2OH +$ $SO_4H_2 + CH_3CO(ONa) = SO_2(OH)(ONa) + \mathbf{CH_3CO(OC_2H_5)}$. **Acetamide** C_2H_3O,H_2N, white crystalline solid, melting at 78° C. From ethyl acetate and H_3N. Also from ammonium acetate $-$ OH_2. Also from $C_2H_3OCl + H_3N = HCl +$ **Acetamide**. Behaves like an acid and a base. By loss of OH_2 into ACETO-NITRILE $(C_2H_3)N$. Heated with ClH into ClH_4N + **Diacetamide** $(C_2H_3O)_2HN$: it is a secondary monamine, just as acetamide is a primary. **Ethyl-acetamide** $(C_2H_5)(C_2H_3O)HN$ is formed from ethylamine and acetyl chloride with loss of ClH. **Lead acetate**

$(C_2H_3OO)_2Pb,3OH_2$ is sugar of lead, in right-rhombic prisms, or in masses of white crystals. Soluble in less than 2 of water. By heat, anhydrous; then fuses. If temperature raised, into PbO,CO_2, and **Acetone** C_2H_3O,CH_3 or acetyl methyl. But acetone is better prepared by distilling CALCIUM ACETATE $(CH_3)_2(COO)_2Ca$ = $CO(O_2Ca)$ + **Acetone.** Colorless liquid. Boils at 56° C. Behaves like an aldehyde, **but** with nascent H_2 yields SECONDARY PROPYL ALCOHOL $CH_3.CHOH.CH_3$ (p. 101). Acetone also, from zinc methide and acetyl chloride: $(CH_3)_2Zn + 2CH_3.COCl = Cl_2Zn + 2\mathbf{CH_3.CO.CH_3}$. Goulard extract is BASIC ACETATE $2PbO,(C_2H_3O)_2O_2Pb,OH_2$. In crystals, by addition of H_3N to acetate of lead. Formed in manufacture of white lead $Pb(OH)_2,2COO_2Pb$. **Copper acetate** $(C_2H_3O_2)_2Cu,OH_2$ in green crystals, soluble in 14 of water. Verdigris is basic acetate. **Silver acetate** $C_2H_3O(OAg)$. small colorless needles, little soluble in water. **Mercurous acetate**, small scales, very little soluble. **Ferric acetate**, dark red-brown, uncrystallizable. Ag, Hg_2, and Fe_2 salts, are tests. **Acetic oxide** is the **Anhydride** $(C_2H_3O)_2O$ = $(C_2H_3O)O(C_2H_3O)$. Heavy oily liquid, slowly *by water* into acetic acid. *Prep.* From acetyl chloride on sodium acetate = $ClNa + \mathbf{(C_2H_3O)_2O}$.

Chloracetic acids. By action of Cl_2 upon acetic acid in sunshine. The Cl substitutes one, two, or three atoms of Hydrogen in ACETYL C_2H_3O. MONO-CHLORACETIC ACID $\mathbf{(CH_2Cl)COOH}$. DI-CHLORACETIC ACID $\mathbf{(CHCl_2)COOH}$. TRI-CHLORACETIC ACID $\mathbf{(CCl_3)COOH}$. With H_3N yields Chloroform (p. 83). **Bromacetic acids. Iodacetic acids. Thiacetic acid** CH_3COSH, by P_2S_5 on $5CH_3COOH = P_2O_5 + 5CH_3COSH$. **Amidacetic acid** $CH_2(H_2N)COOH$ is **Glycocin**, or gelatin-sugar. Transparent crystals easily soluble in water. Prepared by $2H_3N$ upon monochloracetic acid = ClH_4N + glycocin. See hippuric acid, p. 114. Nitrous acid changes it into OXY-ACETIC OR GLYCOLLIC ACID $CH_2OH.COOH + N_2 + OH_2$. **Methyl glycocin or Sarcosin** $CH_2(CH_3.HN)COOH$, colorless, rhombic prisms, isomeric with alanin. By boiling creatin with Baryta water; also by digesting ethyl chloracetate with aqueous solution of methylamin. Thus: $CH_2Cl.COOC_2H_5 + CH_3.H_2N + OH_2 = ClH + C_2H_5OH$ + **methyl-glycocin** $CH_2.HNCH_3.COOH$. It combines with acids to form salts. When heated with soda-lime it gives off methylamin (p. 90).

Amines.—Ethylamine $\mathbf{C_2H_5H_2N} = C_2H_7N$. A primary amine, or ammonia in which the alcohol radicle "ethyl" replaces H atom for atom. On digesting bromethane C_2H_5Br with alcoholic solution of H_3N, ETHYL-AMMONIUM BROMIDE $C_2H_5H_3NBr$ is obtained; on distilling with $CaOOH_2$, Br_2Ca and $2C_2H_5H_2N$ result. *Or*, from ETHYL-ISOCYANATE $NCOC_2H_5$ by $2HOK = CO(OK)_2 + \mathbf{NH_2C_2H_5}$. Mobile liquid of sp. gr. 0.696. Boils at 19° C. Odor of ammonia. White clouds with ClH. Crystallizable

salts. Vapor inflammable. Decomposed by $2NO(OH) = N_2 + 2OH_2 + NO(OC_2H_5)$. **The nitrites of alcoholic radicles thus produced, easily resolved into corresponding alcohols by distillation with KOH.** The iso-cyanides easily prepared from the alcohols, and by nascent H_2 they are changed into **Amines**. Thus we pass from a lower to a higher alcohol. By passing vapor of $CN(OH)$ into $(C_2H_5)H_2N$, we obtain ETHYL-UREA $COH_3(C_2H_5)N_2$. **Diethylamine** $(C_2H_5)_2HN$, by mixing ethylamine with ethyl iodide, &c. **Triethylamine** $(C_2H_5)_3N$. **Tetrethyl-ammonium hydrate** $(C_2H_5)_4N.OH$. From iodide by HOAg. Analogous to KOH. By heat $= (C_2H_5)_3N + OH_2 + C_2H_4$. **Triethylphosphine** $(C_2H_5)_3P$. **Triethylstibine** $(C_2H_5)_3Sb$. By distilling $3(C_2H_5I)$ with an alloy of SbK_3, &c. **Triethylarsine** $(C_2H_5)_3As$, &c. **Triethylbismuthine** $(C_2H_5)_3Bi$.

Metallic compounds of ethyl. POTASSIUM ETHIDE $(C_2H_5)K$ and C_2H_5Na only known in combination with $(C_2H_5)_2Zn$. **Zinc ethide** $(C_2H_5)_2Zn$. United with I_2Zn, by heating IC_2H_5 with Zn in close vessel, and separating by distillation in H. Serves to exchange ethyl for Cl, Br, I and in compounds. Mobile, volatile liquid, burning with greenish flame and depositing ZnO. By water into **Ethane** C_2H_6 and ZINC HYDROXIDE $Zn(OH)_2$. With dry O, first into $C_2H_5Zn(OC_2H_5)$ and then into $C_2H_5OZnOC_2H_5$. With $I_2 = IC_2H_5 + IZnC_2H_5$. Then $IZnC_2H_5 + I_2 = I_2Zn + IC_2H_5$. With MERCURIC CHLORIDE, zinc ethide gives Cl_2Zn + **Mercuric ethide** $(C_2H_5)_2Hg$. **Plumbic ethide** $(C_2H_5)_4Pb$. **Silicon ethide** $(C_2H_5)_4Si$. by zinc ethyl on Cl_4Si. Colorless liquid, boils at 150° C. May be regarded as the ninth paraffin, NONYL C_9H_{20} in which Si replaces C. **Borethide** $(C_2H_5)_3B$, boils at 95° C. From ethyl borate by zinc ethide.

[**A dicarbon monatomic alcohol not belonging to the primary alcohols of the paraffin series is, vinyl alcohol** C_2H_3OH. Prepared by Berthelot from ETHINE C_2H_2, by combining with $SO_2(OH)_2$ to VINYL-SULPHURIC ACID $SO_2(OH)(OC_2H_3)$, and distilling with water. The radical vinyl is univalent. Only two alcohols of this series are known. 1. VINYL ALCOHOL. 2. ALLYL ALCOHOL C_3H_5OH, see p. 102.] **Ethene** or **ethylene** C_2H_4, p. 91, is a dyad radical. It is the basis of a series of diatomic alcohols, derived from the paraffins by substitution of 2OH for 2H. Thus: C_2H_6 becomes $C_2H_4(OH)_2$. 1. **Methene** CH_2 is unknown. Its oxygen compound is CO. [Its glycol, METHENE GLYCOL $(CH_2)''(OH)_2$, cannot attract to itself more than one atom of OH. METHENE ACETATE $(CH_2)''(OC_2H_3O)_2$. Oily liquid. From METHENE IODIDE CH_2I_2 on $C_2H_3O(OAg)$. METHENE OXIDE $(CH_2)''O$ or rather $(CH_2)_3O_3$.] 2. **Ethene alcohol** is **Glycol** $C_2H_4(OH)_2$. Colorless inodorous liquid of sp gr. 1.125. Boils at 197°.5 C. Miscible with water in all proportions. Prepared from ETHENE BROMIDE $C_2H_4Br_2$ by silver acetate $2(CH_3COOAg)$

$= 2BrAg + (C_2H_3O.O)_2C_2H_4$. By distilling acetate of ethene with $Ba(OH)_2 = (C_2H_3OO)_2Ba + C_2H_4(OH)_2$. Potassium may expel one or two atoms of H in OH, and yield mon- or di-ethenate. Ethers of the glycols obtained by treatment with iodmethane. iodethane, &c. Thus: $C_2H_4(OH)(ONa) + C_2H_5I = INa +$ ETHYL ETHENATE $C_2H_4(OH)(OC_2H_5)$. Again: $C_2H_4(ONa)_2 + 2C_2H_5I = 2INa =$ DIETHYL ETHENATE $C_2H_4(OC_2H_5)_2$. Hydroxyl-acids produce ethereal salts, but the hydracids of Cl. Br, I, &c., only remove one atom of OH, forming ETHENE CHLORHYDRATE $C_2H_4OH.Cl$. DICHLORINATED ETHER $C_2H_4Cl_2$ can only be produced from the alcohol by $2Cl_5P = 2ClH + 2POCl_3 +$ ETHENE DICHLORIDE $C_2H_4Cl_2$, the Dutch liquid of Chemistry. $\mathbf{C_2H_4Cl_2}$ is a thin colorless liquid, of ethereal odor; heavier than water. Boils at 82°.3 C. Prepared by mixing Cl_2 with C_2H_4. C_2Cl_6 is a white crystalline, aromatic substance, the analogue of ETHANE C_2H_6'. $\mathbf{C_2Cl_2}$ in white needles, obtained by passing $CHCl_3$ or C_2Cl_6 through a red-hot tube. ETHENE BROMIDE $(C_2H_4)''Br_2$, boils at 129°.5 C. ETHENE IODIDE $C_2H_4I_2$, a crystalline substance, made by acting upon $C_2H_4Cl_2$ with I_2. **Ethene cyanide** $(C_2H_4)''Cy_2$, crystalline, melts at 50° C. By distilling $2CNK + C_2H_4Br_2 = 2BrK + Cy_2(C_2H_4)''$. ETHENE OXIDE $(C_2H_4)''O$, transparent, colorless fluid; boils at 13°.5 C It takes up nascent H_2, and becomes ethyl-alcohol. From ETHENE CHLOR-HYDRIN $C_2H_4OHCl + HOK = ClK + OH_2 +$ ETHENE OXIDE C_2H_4O. It is a powerful base, and unites with H_3N to form basic compounds with 1, 2, 3 and 4 molecules of C_2H_4, of syrupy character and *no* crystalline compounds with acid sulphites. Ethene oxide is thus distinguished from aldehyde or ETHIDINE OXIDE CH_3COH. ETHENE SULPH-HYDRATE $C_2H_4(SH)_2$, colorless oil, insoluble in water. From $C_2H_4Br_2$ by 2SHK. ETHENE SULPHIDE $(C_2H_4)''S,(C_2H_4)''S$. Crystalline solid. Vapor-density 60. ETHENE SULPHONIC ACID $C_2H_4(SO_3H)_2$, difficult to crystallize. By oxydation of the sulph-hydrate of ethene, or by boiling ethyl-alcohol with sulphuric anhydride. $\mathbf{C_2H_4(OH)SO_3H}$ **is isethionic acid**, and isomeric with ETHYL SULPHURIC ACID $C_2H_5HSO_4$. Uncrystallizable liquid, decomposed by boiling with water. AMMONIUM ISETHIONATE $C_2H_4OHSO_3H_4N$, heated to 230° C., into OH_2 and **ethene-amido-sulphonic acid** or **Taurine** $C_2H_4(H_2N)SO_3H$. Isethionic acid, by oxydation of the sulph-hydrate of etheno, *or* by action of nitrous acid on taurine $= N_2 + OH_2 +$ isethionic acid $(C_2H_4)''(OH)SO_3H$.

Taurine $C_2H_4(H_2N)SO_3H$ is found in the bile of oxen, &c., in combination with cholic acid, and is prepared by boiling TAUROCHOLIC ACID $C_{26}H_{45}NSO_7 + OH_2$ with HOK. In rhombic prisms, easily soluble.

ETHIONIC ANHYDRIDE $C_2H_4(SO_3)_2$, in deliquescent needles.

By OH_2 into ETHIONIC ACID $C_2H_4(OSO_2OH)SO_2OH$. Resolved by boiling water into $SO_2(OH)_2$+isethionic acid $C_2H_4(OH)(SO_3H)$. **Glycol $(CH_2OH)_2$ or $C_2H_4(OH)_2$ by oxydation, forms the first of a series of diatomic and monobasic acids. Glycollic acid** $C_2H_4O_3 = CH_2''(OH)(COOH)$ or OXY-ACETIC ACID, is the first of the lactic series, or oxy-fatty acids. Sometimes syrupy liquid, at others crystalline. Sour, very soluble, begins to boil at 100° C. (By dehydrants, from 2 mols. minus OH_2, into dibasic DI-GLYCOLLIC ACID $C_4H_6O_5$.) *Prep.* from Glycol by platinum-black. From glycocin, p 95, by nitrous acid. From bromacetic acid by HOAg. $CH_2Br(COOH) + HOAg = BrAg +$ **$CH_2OHCOOH$**. From OXALIC ACID by $2H_2$. **By further oxydation of a glycol, we obtain a series of diatomic, dibasic acids.** They all contain 4 atoms of O. **1. Oxalic acid** $C_2H_2O_4,2OH_2 = (C_2O_2)''(OH)_2 2OH_2$. Oblique, rhombic prisms, soluble in 8 of water, and in their own weight of boiling water. Poisonous: magnesia or chalk the best antidotes. Reduces Cl_3Au. Thus: $2Cl_3Au + 3[(C_2O_2)''(OH)_2] = 6ClH + 6CO_2 + 2Au$. By SO_4H_2 into $SO_4H_2,OH_2 + CO_2 +$ **CO**. All OXALATES decomposed by heat, generally into carbonate, and Carbonic oxide, sometimes into metal and CO_2, without blackening. $(C_2O_2)''(OK)_2,2OH_2$ in rhombic prisms. $(C_2O_2)''OH.OK,2OH_2$, is salt of sorrel. In *Rumex*, *Oxalis acetosella*, &c. Soluble in 40 of water, and 6 of boiling. QUADROXALATE $(C_2O_2)''OH.OK,(C_2O_2)''(OH)_2$. SODIUM OXALATE very little soluble. AMMONIUM OXALATE $(C_2O_2)''(OH_4N)_2,2OH_2$: by heat into $2OH_2$+OXAMIDE $(C_2O_2)''(H_2N)_2$. Heated with a de-hydrant into $4OH_2$+di-cyanogen C_2N_2. Cyanogen in water $+ (4OH_2) = (C_2O_2)''(OH_4N)_2$. AMMONIUM HYDROXALATE $(C_2O_2)''(OH)(OH_4N),OH_2$. By heat at 232° C., into OXAMIC ACID $(C_2O_2)''(OH)(H_2N)$. CALCIUM OXALATE $(C_2O_2)''O_2Ca$,4aq. white, insoluble in water and in acetic acid. "Mulberry calculus," because often blood-stained. By heat $=CaO,CO_2+CO$. Lime and soluble salts, a *test*. $(C_2O_2)O_2Fe$ nearly insoluble. FERRIC soluble. $(C_2O_2)''(OC_2H_5)_2$ is **oxalic ether.** Colorless, oily liquid of aromatic odor, and 1.09 sp. gr. Boils at 183°.8 C., little soluble in water. With $2H_3N$ into ethyl-alcohol and OXAMIDE $(C_2O_2)''(H_2N)_2$. With dry gaseous ammonia, ethyl oxalate yields alcohol, and ETHYL OXAMATE $(C_2O_2)''(H_2N)(OC_2H_5)$. **Oxamide** $(C_2O_2)''(H_2N)_2$ a white powder, insoluble in water and in alcohol. Its vapor through red-hot tube: $2(C_2O_2)''(H_2N)_2 = CO''(H_2N)_2 + CNH + H_3N + CO + CO_2$. It is formed when $2CNH + O_2H_2$ are brought together. By dilute acids into oxalic acid and an ammonium salt. DI-METHYL OXAMIDE $(C_2O_2)''(CH_3)_2NH_2N$., &c. ETHYL CARBONATE $(CO)''(OC_2H_5)_2$ by K or Na upon ethyl oxalate: CO evolved. METHYL OXALATE $(C_2O_2)''(OCH_3)_2$, in transparent rhombs. Melts at 53° C. Boils at 161° C. With dry H_3N into methyl

oxamate $(C_2O_2)''(H_2N)OCH_3$. ETHENE OXALATE $(C_2O_2)''(OCH_2)_2$ from silver oxalate by $C_2H_4Br_2$. *Prep.* of **oxalic acid**. 1. From calcium oxalate by $SO_2''(OH)_2$. 2. from sugar by oxydation with nitric acid: $C_{12}H_{22}O_{11} + 9O_2 = 5OH_2 + 6$ oxalic acid. 3. by heating potassium-amalgam in CO_2; or Na_2 in $2CO_2 = (C_2O_2)''(ONa)_2$. 4. Upon a large scale, by heating sawdust with mixt $KOH + 2NaOH$ at about 204° C. and treatment with water, which leaves sodium oxalate undissolved. From $(C_2O_2)''(ONa)_2 + Ca(OH)_2 = (C_2O_2)''(O_2Ca) + 2NaOH$. From calcium oxalate by sulphuric acid: $(C_2O_2)''O_2Ca + SO_2(OH)_2 = SO_2O_2Ca + \mathbf{(C_2O_2)''(OH)_2}$.—**2. Malonic acid** $C_3H_4O_4 = (C_3H_2O_2)''(OH)_2 = \mathbf{(CH_2)''(COOH)_2}$; rhomboids. Melts at 140° C. At 150° C. into $CO_2 + (CH_3)COOH$. By oxydizing malic acid + $O_2 = CO_2 + OH_2$ + malonic acid. Also by oxydation of PROPENE-GLYCOL $(C_3H_6)''(OH)_2$. [NITRO-MALONIC ACID $(CH)(NO)(COOH)_2$, in fusible needles: explosive. AMIDO-MALONIC ACID $CH(H_2N)(COOH)_2$, by nascent H_2 upon the nitro-compound. Shining prisms. By heat into CO_2 and AMIDACETIC ACID $CH_2(H_2N)COOH$ or glycocin.]

Mesoxalic acid $CO(COOH)_2 = C_3H_2O_5$ by substitution of O for H_2 in MALONIC ACID $CH_2(COOH)_2$. Deliquescent prisms, containing OH_2. Melts at 115° C. By oxydizing amido-malonic acid $CH(NO)(COOH)_2 + O = H_3N + \mathbf{CO(COOH)_2}$. Also from alloxan + $2OH_2$ (boiled with alkalies) $= CO(H_2N)_2 + CO(COOH)_2$. Nascent H_2 converts mesoxalic acid into TARTRONIC ACID $CH(OH)(COOH)_2$.

3. Succinic acid $\mathbf{(C_2H_4)''(COOH)_2} = C_4H_6O_4 = (C_4H_4O_2)''(OH)_2$. Colorless oblique rhombic prisms, soluble in 5 of cold and 3 of boiling water. Melts at 180° C.; boils at 235° C., loses OH_2 and becomes SUCCINIC OXIDE or ANHYDRIDE $(C_4H_4O_2)''O$. Also: $C_2H_4(COOH)_2 + Cl_5P = Cl_3OP + 2ClH + (C_4H_4O_2)''O$. Alkaline succinates readily soluble. FERRIC SUCCINATE, red-brown precipitate, dissolved by ClH. Succinates, not **precipitated** from salts by acids, *but*, in the cold, by Cl_2Ba, **after** addition of H_3N *and alcohol*. Succinic acid exists ready formed in amber (*succinum*). Most easily obtained by fermenting calcium malate. (*See* MALIC ACID $C_2H_3(OH)(COOH)_2$, p. 105.) Also by oxydizing BUTYRIC ACID $C_3H_7(COOH) = OH_2$ + **succinic acid.** Also by action of IH upon malic acid. Thus: $C_2H_3OH(COOH)_2 + 2IH = I_2 + OH_2$ + **succinic acid.**—Also from ETHENE CYANIDE $(C_2H_4)''C_2N_2$ by alcoholic potassoxide. Thus: $(C_2H_4)''C_2N_2 + 2HOK + 2OH_2 = 2H_3N$ + POTASSIUM SUCCINATE. $(C_2H_4)''(COOK)_2$. Also by nascent H_2 to FUMARIC ACID $(C_2H_2)''(COOH)_2$. **Monobromsuccinic acid** $C_2H_3Br(COOH)_2$ by heating the acid with Br_2 and water in sealed tubes to 160° C. In groups of needles, easily soluble. Melts at 160° C., evolves BrH, and becomes fumaric acid. By boiling with HOAg, into BrAg and **malic**

acid $C_2H_3OH(COOH)_2$. **Di-bromsuccinic acid** $C_2H_2Br_2(COOH)_2$ in prisms. By 2HOAg into inactive **tartaric acid** $C_2H_2(OH)_2(COOH)_2$. [SUCCINYL CHLORIDE $(C_2H_4)''(COCl)_2$. Oily liquid, produced by action of PCl_5 upon succinic acid.] [Belonging to the same group, as 1. OXALIC ACID $(C_2O_2)''(OH)_2$, p. 98; 2. MALONIC ACID $(CH_2)(COOH)_2$, p. 99; 3. SUCCINIC ACID $(C_2H_4)''(COOH)_2$, p. 99; we have to mention: 4. **pyro-tartaric acid** $(C_3H_6)(COOH_2)$. 5. **Adipic acid** $(C_4H_8)''(COOH)_2$. 6. **Pimelic acid** $(C_5H_{10})''(COOH)_2$. 7. **Suberic acid** $(C_6H_{12})''(COOH)_2$, white crystalline powder. 8. **Anchoic acid** $(C_7H_{14})''(COOH)_2$. 9. **Sebasic acid** $(C_8H_{16})''(COOH)_2$. In pearly scales; melts at 127° C. 10. **Brassylic acid** $(C_9H_{18})''(COOH)_2$. 11. **Roccellic acid** $(C_{15}H_{30})''(COOH)_2$.]

III. Tricarbon C_3 or Propane group C_3H_6.

All compounds which contain three carbon atoms linked together are derived from the paraffin **propane** $C_3H_8 = CH_3-CH_2-CH_3$.

Propane $C_3H_8 = CH_3-CH_2-CH_3$, is a gas, liquefying at −20° C. Methyl-ethyl. By action of zinc and 2ClH on (2) PROPYL IODIDE C_3H_7I. Also contained in petroleum. Exposed to Chlorine in sunlight, partly into PROPYL CHLORIDE C_3H_7Cl. Colorless liquid. Boils at 47° C. Also from normal propyl alcohol by ClH. PSEUDOPROPYL CHLORIDE $CH_3-CHCl-CH_3$, boils at 37° C. PROPYL IODIDE $\mathbf{CH_3-CH_2-CH_2I}$ or C_3H_7I, boils at 102° C. PSEUDOPROPYL IODIDE $CH_3-CHI-CH_3$, an oily liquid of sp. gr. 1.7. Bromine expels iodine. Best prepared by action of HYDROGEN IODIDE IH upon GLYCERIN; $C_3H_5(OH)_3 + 5IH = 2I_2 + 3OH_2 + \mathbf{C_3H_7I}$. By nascent $H_2 = IH + \mathbf{C_3H_8}$ or normal PROPANE; C_3H_8 by Cl_2 into normal PROPYL CHLORIDE $\mathbf{C_3H_7Cl}$ or $CH_3-CH_2-CH_2Cl$, and this, heated with potassium acetate, yields normal PROPYL ACETATE. Now normal propyl acetate, heated in sealed tubes with HOK, gives potassium acetate and **normal propyl alcohol** $CH_3-CH_2-CH_2OH$. **A generic method of obtaining the normal from the abnormal.**

Primary propyl alcohol $C_3H_7OH = CH_3-CH_2-CH_2OH$. In this, as in other primary alcohols, hydroxyl is attached to a carbon-atom at the end of the chain. Also: **Ethyl-carbinol.** Boils at 96° C. Freely soluble in water. In the residues of certain French brandies. From PROPIONIC ALDEHYDE CH_3-CH_2-COH by nascent $H_2 = \mathbf{CH_3-CH_2-CH_2OH}$. Also from ETHYL CYANIDE $CH_3-CH_2.CN$ by $2H_2$ into PROPYLAMINE $CH_3-CH_2-CH_2H_2N$; this by $2NO(OH)$ into $2OH_2 + N_2 +$ PROPYL NITRITE. Then: $NO(OC_3H_7) + HOK = NO(OK) + \mathbf{C_3H_7OH}$.—**Propylic aldehyde** CH_3-CH_2-COH or $\mathbf{C_3H_6O}$, of sp. gr. 0.804. Boils at 49° C. Resembles acetic aldehyde. Obtained by oxydizing the normal alcohol, or by distilling a mixture of calcium

formate and propionate: $(CH_3\text{-}CH_2COO)_2Ca$ + $(H\text{-}COO)_2Ca$ = $2CO_3Ca$ + **propylic aldehyde** (2 mols.).—**Propionic acid** $C_2H_5COOH = \mathbf{C_3H_6O_2}$. Is the **third** of the series of the fatty acids, of which FORMIC ACID **H.COOH**, is the **first**, and ACETIC ACID **CH_3-COOH**, is the **second**. Colorless liquid, of sp. gr. 0.992. Soluble in water; the PROPIONATES also. *Prep.* From ETHYL CYANIDE $C_2H_5CN + HOK + OH_2 = H_3N$ + POTASSIUM PROPIONATE, and from this by distillation with $PO(OH)_3$. Also from LACTIC ACID $C_3H_6O_3 + 2IH = I_2 + OH_2 + \mathbf{C_2H_5.COOH}$. [CHLORO-PROPIONIC ACID **CH_3-CHCl-COOH**. Dense liquid of sp. gr. 1.28. Boils at 186° C. Prepared from lactyl chloride by OH_2, and changed when heated with HOAg, into ClAg and lactic acid. BROMO-PROPIONIC ACID $\mathbf{C_3H_5BrO_2}$, is solid at − 17° C., and boils at 202° C. From propionic acid by Br_2 or from lactic acid by 2BrH. Alcoholic H_3N changes it into **Alanine** or AMIDO-PROPIONIC ACID **CH_3-CH(H_2N)-COOH**. Crystallizes in tufts of needles, soluble in 5 of water. Quickly heated, into CO_2 and ethylamine. Nitrous acid converts it into **lactic acid**. **Propionamide** C_3H_5O,H_2N, resembles ACETAMIDE C_2H_3O,H_2N. Melts at 75° C.]

Secondary propyl alcohol $C_3H_7OH = \mathbf{CH_3\text{-}CHOH\text{-}CH_3}$. "Pseudo-propyl alcohol." The **OH** is placed between two other carbon-atoms, as in all secondary alcohols. Isomeric, but differing in properties and results of decomposition. Also called DI-METHYL CARBINOL. Boils at 84° C. Forms definite hydrates. From ISO-PROPYL IODIDE by SILVER acetate, AND from iso-propyl acetate by HOK. On **oxydation** yields a **ketone** (not an aldehyde). Thus: $CH_3\text{-}CHOH\text{-}CH_3$ *minus* $H_2 = CH_3\text{-}CO\text{-}CH_3$ or **Acetone** $\mathbf{C_3H_6O}$ (p. 95). Nascent hydrogen H_2, changes acetone into secondary propyl alcohol. Acetone, by further oxydation $2O_2 = CO_2 + OH_2$ + ACETIC ACID CH_3COOH. [Chlorine may substitute H, atom for atom in acetone. Under the influence of ClH, acetone may become: MESITYL-OXIDE $C_6H_{10}O$; PHORONE $C_9H_{14}O$, and MESITYLENE C_9H_{12}.]

Propene C_3H_6, colorless gas, condensable. In coal-gas. With IH forms SECONDARY PROPYL IODIDE $CH_3.CHI.CH_3$. By nascent H or IH on ALLYL IODIDE C_3H_5I. *Or*, by heating HOK with PROPYL IODIDE $C_3H_7I = OH_2 + IK + \mathbf{C_3H_6}$. **Propene glycol** $(C_3H_6)''(OH)_2$, is the third diatomic alcohol. Colorless, oily liquid, of sweet taste. Boils at 188° C. By contact with Platinum black into LACTIC ACID $CH_3.CHOH.COOH$, and OH_2. Gaseous ClH into PROPENE CHLORHYDRIN $CH_3.CHOH.CH_2Cl$. The glycol, by distilling PROPENE ACETATE $(CH_3.COO)_2C_3H_6$ with $2KOH = 2CH_3COOK + \mathbf{(C_3H_6)''(OH)_2}$.

Propene oxide $(C_3H_6)''O$, is a volatile liquid, readily soluble in water; boils at 35° C. By aqueous HOK upon propene chlorhydrin.

Propenyl alcohol or Glycerin $(C_3H_5)'''(OH)_3$ is a **triatomic alcohol.** By substituting $3(OH)$ for $3H$ in a PARAFFIN, we obtain a triatomic alcohol. **Methenyl alcohol** $(CH)'''(OH)_3$, and **ethenyl alcohol** $(C_2H_3)'''(OH)_3$ are unknown. **But most natural fats are the ethers of propenyl, or glycerides.** *E.g.* PALMITIN $(C_3H_5)'''(OC_{16}H_{31}O.)_3$ is palmitate of propenyl. When boiled with $3K(OH)$ = **palmitate of K** $3[(C_{16}H_{31}O(OK)]$ and **glycerin.** The same result in saponification. Glycerin made originally by heating olive-oil (OLEATE OF PROPENYL) with LEAD-OXIDE and OH_2: "lead-plaster" or lead oleate, as an insoluble soap is obtained, and glycerin. **Now** prepared, by action of super-heated steam upon **stearin** or STEARATE OF PROPENYL $(C_3H_5)'''(OC_{18}H_{35}O)_3$ + 3 WATER = **glycerin** $(C_3H_5)'''(OH)_3$ + STEARIC ACID $3[C_{18}H_{35}O.OH]$. Glycerin is a colorless, viscid liquid, of sp. gr. 1.27. In form of crystals, it melts at 15°.5 C. Very sweet, does not ferment, but with yeast, gradually, into propionic acid. Heated, it volatilizes in part, slightly darkens, leaves no residue, and evolves pungent vapors of acrolein. As ETHYL ALCOHOL by O_2 into **acetic acid** $CH_3.COOH$; ETHENE GLYCOL + O_2 into **glycollic acid** $CH_2OH.COOH$, so also glycerin by O_2 into **glyceric acid** $C_3H_6O_4$ and WATER. Treated with concentrated NO_2OH, into GLONOIN or **nitro-glycerin** $CH_2(ONO_2).CH(ONO_2).CH_2(ONO_2)$, a heavy oily liquid. Explodes by percussion. SULPHOGLYCERIC ACID $C_3H_5(OH)_3SO_3$. PHOSPHO-GLYCERIC ACID in the brain and in yelk of eggs. Monatomic hydroxyl acids when heated in sealed tubes with glycerin, form WATER, and compound ethers. Thus: MON-ACETIN $C_3H_5(OH)_2OC_2H_3O$; DI-ACETIN $C_3H_5(OH)(OC_2H_3O)_2$; TRI-ACETIN $C_3H_5(OC_2H_3O)_3$. **Glycerides** thus produced. The hydrogen acids can only remove up to two atoms of OH. Thus: **monochlorhydrin** $C_3H_5(OH)_2Cl$ and **dichlorhydrin** $C_3H_5(OH)Cl_2$. Only by PCl_5 can we obtain **trichlorhydrin** $C_3H_5Cl_3$. Thus: $C_3H_5(OH)Cl_2 + Cl_5P = POCl_3 + ClH + \mathbf{C_3H_5Cl_3}$. [BrH like ClH. HI differently; $C_6H_{10}O_2(OH)I$. **Epi-chlorhydrin** C_3H_5OCl by treating dichlorhydrin with HOK. By heating the mono- or di-chlorhydrins with sodium alcohol, we obtain MON-ETHYLIN $C_3H_5(OH)_2C_2H_5$ and DI-ETHYLIN $C_3H_5(OH)(C_2H_5)_2$. **Poly-glycerins** also exist.]

Allyl compounds. Allyl alcohol $CH_2.CH.CH_2OH = C_3H_5OH$. Colorless liquid, of pungent odor. Very soluble in alcohol, ether and water. Boils at 103° C. Inflammable primary alcohol. *Prep.* from **allyl oxalate** $C_2O_2(OC_3H_5)_2$ by $2H_3N$ = OXAMIDE $C_2O_2(H_2N)_2$ + **allyl alcohol. Allyl iodide** C_3H_5I, is a liquid of sp. gr. 1.78; boils at 100° C. *Prep.* by distilling propenyl alcohol with phosphorus tetriodide. Thus: $2[(C_3H_5)'''(OH)_3] + P_2I_4 = I_2 + 2PO H(OH)_2$ + **allyl iodide** $2C_3H_5I$. Treated with SILVER OXALATE $C_2O_2(OAg)_2$, yields SILVER IODIDE AgI and **allyl oxalate.** By treatment with phosphoric anhydride, allyl alcohol

gives allylene C_3H_4. Oxygen (by platinum black, or better by distillation with potassium di-chromate and sulphuric acid) produces **Acrolein** or **acrylic aldehyde** C_3H_4O, and acrylic acid $C_3H_4O_2$. ACROLEIN **CH_2–CH–COH**, is a thin, colorless, volatile liquid, lighter than water; boils at 52°.2 C. Its vapor is fearfully irritating. By nascent H_2 into allylic alcohol. With H_3N into OH_2 and acrolein-ammonia. **Acrylic acid** is the **first** of the **acrylic series,** of the general formula $C_nH_{2n-2}O_2$. ACRYLIC ACID $C_2H_3COOH = C_3H_4O_2$. Colorless liquid of pungent, aromatic odor, soluble in water. Melts at 7° C. Boils at 139° C. By nascent H_2 into propionic acid. [CROTONIC ACID $C_3H_5COOH = C_4H_6O_2$. ANGELIC ACID $C_4H_7COOH = C_5H_8O_2$, in the root of *Angelica Archangelica.* HYPOGÆIC ACID $C_{15}H_{29}COOH = C_{16}H_{30}O_2$, as a glyceride in *Arachis hypogæa.*] [**Oleic acid** $C_{17}H_{33}COOH = C_{18}H_{34}O_2$, **belongs to the acrylic series.** Obtained by the saponification of olein or ter-oleate of propenyl, the fluid portion of most oils and fats. **Olein** $(C_3H_5)(OC_{18}H_{33}O)_3$, best exemplified by olive oil, which. below 4° C., deposits solid PALMITIN. Oleic acid crystallizes in white needles; melts at 14° C. Sp. gr. 0.898. Neutral to test-paper. Insoluble in water. OLEATES.] **Allyl cyanide** CNC_3H_5, is found in oil of mustard. **Iso-cyanide of allyl** NCC_3H_5, formed by digesting allyl iodide with silver cyanide. **Allyl sulpho-cyanide** $NCSC_3H_5$, chief constituent of oil of mustard. Excites to tears. Boils at 148° C. By H_3N into **thiosinamin** or **allyl sulpho-urea** $CS(H_2N)(NH.C_3H_5)$. **Allyl sulphide** $S(C_3H_5)_2$. In *Allium sativum.*

Among important tri-carbon compounds, belongs lactic acid, of the same series as **glycollic,** or **oxy-acetic acid.** [1. CARBONIC ACID $CO(OH)_2$. 2. GLYCOLLIC ACID $CH_2OH.COOH$.] 3. **Lactic acid** $C_3H_6O_3$, or **oxy-propionic acid** $(C_2H_4)''(OH)(COOH)$. TWO MODIFICATIONS. **Ordinary lactic,** or **methyl-lactic acid** $CH_3.CHOH.COOH = C_3H_6O_3$. Colorless syrup, of sp. gr. 1.215. Very sour, and soluble in water, alcohol, and ether. Inactive in its relations to polarized light. LACTATES. $(C_3H_5O_3)_2Ca,5OH_2$. Nodular group of needles, soluble in 9.5 parts of water. $(C_3H_5O_3)_2Zn,3OH_2$, slender needles, soluble in 58 of cold water. When lactic acid heated, forms **anhydride,** or **lactide** $C_3H_4O_2$, and **di-lactic acid** $C_6H_{10}O_5$. LACTYL CHLORIDE $C_3H_4OCl_2 = C_2H_4Cl.COCl$. Colorless liquid, by water into ClH and chloro-propionic acid. *Prep.* of **iso-lactic acid.** By fermentation: GLUCOSE $C_6H_{12}O_6$ = 2 **lactic acid. Lactose** $C_{12}H_{22}O_{11} + OH_2$ = 4 **lactic acid.**—By oxydation of **propene glycol.**—By contact for some days of $CH_3COH + CNH + ClH + 2(OH_2) = ClH_4N$ + lactic acid.—By HNO_2 upon AMIDO-PROPIONIC ACID or **alanine.** By moist **HOAg** on **chloro-propionic acid** $CH_3.CHCl.COOH$. (And lactic acid by 2HI into propionic acid.)—**Sarco-lactic, para-lactic,** or **ethene-lactic acid** $C_2H_4.OH.COOH$, exists in muscular

flesh. Turns the plane of polarization to the left. CALCIUM PARALACTATE, $4OH_2$, is soluble in 12 of cold water. ZINC PARALACTATE, $2OH_2$, in thick, shining prisms, soluble in 17 of cold water. Heated to 130°, paralactic acid yields dilactic acid, changed by water into iso-lactic or ordinary lactic acid.

IV. Tetracarbon group C_4. Butane C_4H_{10} series.

Butane or **Quartane** C_4H_{10}. As normal (diethyl), $\mathbf{CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3}$ a colorless gas, liquid at 0° C. In petroleum. By heating $2IC_2H_5 + Zn = I_2Zn + \mathbf{C_4H_{10}}$. **As iso-butane** $\mathbf{(CH)(CH_3)_3}$, a gas, liquid below − 17° C. **Butyl** or **tetryl alcohol** is PROPYL CARBINOL $CH_3.CH_2.CH_2.CH_2OH$ boils at 115° C., lighter than water, and but little soluble. *Prep.* from BUTYL CHLORIDE $C_4H_9Cl + CH_3.COOK = ClK + CH_3.COO(C_4H_9)$. Then: $2[CH_3,COOC_4H_9] + (OH)_2Ba = (CH_3.COO)_2Ba + \mathbf{C_4H_9OH}$. Also from BUTYRIC ALDEHYDE $CH_3.CH_2CH_2COH$, by nascent H_2. Also from PROPENYL NITRILE C_3H_7CN by nascent H_2 into **butyl-amin** $C_4H_9H_2N$; the latter into BUTYL NITRITE by NOOH, and distilling the nitrite with HOK. By oxydation into **butyric acid** $CH_3.CH_2.CH_2.COOH$. [1. FORMIC ACID H.COOH. 2. ACETIC ACID $CH_3.COOH$. 3. PROPIONIC ACID $CH_3.CH_2COOH$.] 4. **Butyric acid** $CH_3.CH_2.CH_2.COOH$. This acid in juice of muscle. in perspiration; as butyrin or propenyl butyrate in butter. A viscid liquid, of rancid odor, easily soluble in water and in alcohol. Sp. gr. 0.958. Solid at − 12° C.; boils at 163° C. In fermentation of lactose, in presence of chalk, first calcium lactate, and then with evolution of $2CO_2$ and $2H_2$ into calcium butyrate. $2C_3H_6O_3 = 2CO_2 + 2H_2 +$ **butyric acid** $C_4H_8O_2 = \mathbf{C_4H_7OH}$. CALCIUM BUTYRATE, OH_2, shining scales, less soluble in boiling water. ETHYL BUTYRATE $C_4H_7OO.C_2H_5$. PROPENYL NITRILE C_3H_7CN, by heating with HOK, $+ OH_2 = H_3N +$ POTASSIUM-BUTYRATE $CH_3.CH_2CH_2.COOK$. [ISO-BUTYL ALCOHOL $CH_3.CH_2.HCOH.CH_3$, in fousel oil. Soluble in 10½ parts of water. Boils at 110° C. By oxydation into ISO-BUTYRIC ACID $CH(CH_3)_2COOH$. SECONDARY BUTYL ALCOHOL OF METHYL ETHYL ALCOHOL $CH_3C_2H_5.CHOH$. a colorless oily liquid, of burning taste and pungent odor. Sp. gr. 0.85; boils below 97° C. At 250° C., into OH_2 + **butene** C_4H_8. *Prep.* from secondary butyl iodide by HOAg.]

[**Erythrite** $C_4H_6(OH)_4$ or **phycite** $C_4H_{10}O_4$. is the tetratomic alcohol from which secondary butyl iodide is prepared by heating it with $7HI = 4OH_2 + 3I_2 + C(CH_3)(C_2H_5)HI$. A sugar, crystallizing in transparent prisms, readily soluble. Is found in *Protococcus vulgaris*. TERTIARY BUTYL ALCOHOL $C(CH_3)_3OH$, in rhombic prisms, melting at 25°.5 C. Boils at 82°.5 C. By oxydation into acetic acid and acetone. *Prep.* CH_3COCl +

$(CH_3)_2Zn = ZnO + C(CH_3)_3Cl$. Then : $C(CH_3)_3Cl + OH_2 = ClH + C(CH_3)_3OH$.]

Malic acid $C_2H_3OH(COOH)_2 = C_4H_6O_5$. OXY-SUCCINIC ACID. Already seen at p. 99, that in ordinary succinic acid, CH_2 can exchange **both atoms of H** for **OH**, and thus, from mono-bromsuccinic acid we obtain by AgOH, silver bromide and malic acid. Naturally in many acid fruits; apples, gooseberries, *Sorbus aucuparia*, *Rumex*, &c. Tri-atomic; di-basic. Colorless prisms, deliquescent. Also soluble in alcohol. Loses OH_2 at 13c° C., and at 175° C. into MALEIC ACID $C_4H_4O_4$ and FUMARIC ACID $C_4H_4O_4$ or $(CHCOOH)_2$. [Fumaric acid into succinic acid by nascent H_2.] By reducing agents into succinic acid. Acid and neutral salts. LEAD MALATE insoluble in water. AMMONIUM ACID MALATE in crystals. CALCIUM MALATE sparingly soluble: acid salt, crystallized from nitric acid; with $8OH_2$. **Asparagin** $C_2H_3(H_2N)CO.H_2N.COOH$ is the amide of malic acid. In asparagus, marsh-mallow, &c. In lustrous, rhombic prisms $C_4H_8N_2O_3,OH_2$. Insoluble in alcohol and ether. By fermentation into ammonium succinate. [ASPARTIC ACID $CH(H_2N)(COOH).CH_2.COOH$ may be regarded as amido-succinic acid: by $NO(OH)$ into **Malic acid**, $+ N_2 + OH_2$.]

Tartaric acid $C_2H_2(OH)_2(COOH)_2 = C_4H_6O_6$. Tetratomic and dibasic. DEXTRO-TARTARIC ACID is the acid of grapes, tamarinds, pine-apples, &c. Transparent, mono-clinic prisms, very soluble in water and in alcohol. Sour: not corrosive. Melts at 135° C. and at 170° C. into inactive mesotartaric acid. Heated to 204° C. it loses OH_2 and becomes **anhydride** $C_4H_4O_5$. Chars; evolves smell of burnt sugar, carbonizes and burns away without residue. With $2KOH = C_2O_2.OH.OK + CH_3.COOK + 2OH_2$. Dissolves $Fe_2(OH)_6$, and dries to brown, glassy substance: not precipitated by ammonia. POTASSIUM TARTRATE $C_2H_2(OH)_2(COOK)_2$, very soluble. By neutralizing the acid salt with $CO(O_2Ca)$ as in the preparation of the acid: POTASSIUM ACID TARTRATE $C_2H_2(OH)_3COOH.COOK$, is *Cream of tartar*. White gritty powder, requiring 180 parts of cold and 6 of boiling water. *Argol*. Decomposed by heat, carbonizes, inflames, and leaves $CO(OK)_2$ and charcoal. KOH and NH_3 in solution, *acid remaining in excess*, give characteristic, white, crystalline precipitates of $C_4H_4O_4(OH)(OK)$ and $C_4H_4O_4(OH)(OH_4N)$, respectively. *Rochelle salt* is $C_4H_4O_4(ONa)(OK)$,4aq. In large transparent rhombic prisms, soluble in $1\frac{1}{2}$ parts of water. CALCIUM TARTRATE is insoluble: lime-water precipitates tartaric acid. **Tartar emetic** $2[C_4H_4O_4(OSb)OK],OH_2$, in rhombic octahedra, soluble in 15 of cold and 3 of boiling water. Also with (OAs) instead of (OSb). The basic hydrogen of hydroxyl in tartaric acid is displaceable by one or two alcohol-radicles. **Racemic** or **paratartaric acid** crystallizes with one mol. of water, in rhombic prisms. No action

on polarized light. In the grapes of the Vosges, and of the Upper Rhine. Artificially by boiling **dibrom-succinic acid** $C_2H_2Br_2(COOH)_2$ with $2Ag(OH)$. ; it is, however, mixed with inactive tartaric acid.

V. Pentacarbon C_5 group. Pentane C_5H_{12} series.

Pentane or **ethyl propyl** $C_5H_{12} = C_2H_5.C_3H_7$. In petroleum. A liquid of sp. gr. 0.6, boiling at 37° C. [Also ISOPENTANE.] No less than eight pentyl alcohols. **Butyl carbinol** $CH_2.CH_2.CH_2CH_3CH_2OH$ is the normal primary pentyl alcohol. From normal butyl alcohol, *a.* into $CH_2.CH_2.CH_2.CH_3.CN$; *b.* into $CH_2.CH_2.CH_2.CH_3.COOH$; *c.* into VALERIC ALDEHYDE $CH_2.CH_2.CH_2.CH_3$ **COH**, a limpid, pungent fluid, of sp. gr. 0.82, boiling at 96° C. ; and *d.* into the alcohol by nascent hydrogen. Boils at 135° C. By nascent oxygen into **propyl-acetic** or **normal valeric acid** $C_4H_9.COOH$, the fifth of the fatty acids. Oily liquid, of sp. gr. 0.957 ; boils at 185° C. Smells like butyric acid. **Iso-butyl carbinol** $CH.(CH_3)_2.(C_2H_4OH)$ is the common amylic alcohol of fermentation, known as *fousel-oil.* Oily, colorless, mobile liquid, of peculiar odor, and burning acrid taste; sp. gr. 0.825 ; boils at 130° C. Little soluble in water; very soluble in alcohol and ether. Exerts rotatory action on polarized light. Burns with blue flame. By platinum black or nascent Oxygen into **iso-valeric acid** $CH_2.CH(CH_3)_2.COOH$, or common valerianic acid. In root of Valerian, Angelica, the berries of *Viburnum Opulus*, &c. Colorless liquid, of sp. gr. 0.947, boiling at 175° C. Odor of valerian. Burns when inflamed. Iso-valerates of zinc and bismuth used in medicine. **Iso-pentyl chloride** is an inflammable liquid. **Iso-pentyl iodide** $CH.(CH_3)_2.C_2H_4I$, heated to 290° C. in sealed tubes, yields **decane** or **diamyl** $C_5H_{11}.C_5H_{11}$. ZINC-AMYLIDE $(C_5H_{11})_2$ Zn formed at same time, changed by OH_2 into OZn + 2 mols. of **pentane.** **Amyl-ether** $C_5H_{11}.O.C_5H_{11}$; colorless oily liquid. **Amyl acetate,** fragrant liquid, with odor of Jargonelle pears. **Iso-pentene** or **amylene** C_5H_{10}, is a colorless, mobile liquid, obtained from the iso-butyl alcohol by distilling with Cl_2Zn, or P_2O_5. **Iso-pentene glycol** $C_5H_{10}(OH)_2$. is the only amylene glycol known. Prepared from the acetate, like the other glycols (p. 96). by distilling with $Ba(OH)_2$. **Iso-pentenyl alcohol** is **amyl glycerin** $(C_5H_9)(OH)_3$. Dense, colorless liquid, of aromatic taste. Soluble in water.

[PYRO-TARTARIC ACID or **methyl-succinic acid** $CH_3.CH.COOH.CH_2.COOH$, by dry distillation of tartaric acid, and by nascent H_2 upon itaconic, citraconic, and mesaconic acids. Small, rhombic prisms, by loss of water into tartaric anhydride (p. 105).

Uric acid and its derivatives. URIC ACID $C_5H_4N_4O_3$, a white

crystalline powder, without taste or smell. Requires 10,000 parts of water for solution. Insoluble in alcohol and ether. Soluble without decomposition in hot oil of vitriol. In the urine of men and animals; 0.037 per cent. in human urine. Serpent's dung consists of uric acid and ammonium urate. In destructive distillation, uric acid yields CO_2, CNH, CNOH, $CO(OH_4N)_2$ and a coaly residue rich in N. Di-basic. **$C_5H_2N_4O.OH.OK$**, requires 500 parts of cold water. SODIUM URATE constitutes "chalk-stones." AMMONIUM URATE requires 1000 parts of water for solution. When uric acid is evaporated with NO_2OH, a deep-red tint is produced, which becomes purple with H_3N (murexid $C_8H_4(H_4N)N_5O_6$). On heating uric acid with hydrogen iodide, $+ 5OH_2$, it is resolved into glycocin, $+ 3CO_2 + 3H_3N$. **Alloxan** $C_4H_2N_2O_4,4OH_2$ in rectangular prisms, anhydrous at 150° C. By the action of strong nitric acid upon uric acid, urea is formed, but decomposed by the nitrous acid: **$C_5H_4N_4O_3$** $+ OH_2 + O =$ **$C_4H_2N_2O_4$** $+ CO(NH_2)_2$. It may be regarded as MESOXALYL-UREA, in which mesoxalyl (C_3O_3) takes the place of H_2. It stains the skin red, and gives a blue color with ferrous salts. Boiled with $2H_3N = 2OH_2 +$ MYCOMELIC ACID $C_4H_4N_4O_2$. With dilute acids, into OXALIC ACID and UREA. Its aqueous solution when boiled: $3C_4H_2N_2O_4 =$ ALLOXANTIN $C_8H_4N_4O_7 +$ PARABANIC ACID $C_3H_2N_2O_3 + CO_2$. **Alloxanic acid** $C_4H_4N_2O_5$, on boiling with water, $+ OH_2$, is resolved into UREA $CO(H_2N)_2 +$ MESOXALIC ACID $C_3O_3(OH)_2$ (p. 99). Mesoxalic acid $+ H_2 =$ TARTRONIC ACID $C_3H_4O_5 = CH.OH(COOH)_2$, a tri-atomic and di-basic acid, in the same series as MALIC ACID $CH.OH.COOH.CH_2.COOH$. **Parabanic acid** $C_3H_2N_2O_3 = CO.''(HN.CO)_2$ or OXALYL-UREA, is formed by the action of nitric acid, and heat upon ALLOXAN or upon URIC ACID: $C_5H_4N_4O_3 + O_2 + 2OH_2 = 2H_3N + 2CO_2 + C_3H_2N_2O_3$. It is di-basic. In presence of alkalies, it takes up water, and is changed into OXALURIC ACID $C_3H_4N_2O_4$. When parabanic acid is neutralized with H_3N and boiled, AMMONIUM OXALURATE is deposited in crystals on cooling. **Alloxantin** $C_8H_4N_4O_7,3OH_2$, is a product of the reduction of alloxan. $2C_4H_2N_2O_4 + SH_2 = OH_2 + S +$ **$C_8H_4N_4O_7$**. Small colorless prisms. Prolonged action of hydrogen sulphide upon alloxan gives rise to **dialuric acid** $C_4H_4N_2O_4$. Easily accomplished by moist sodium amalgam. **Dialuric acid** may be regarded as **tartronyl-urea** $C_4O_4(H_2N)_2$. **Purpuric acid** $C_8H_5N_5O_6$ as AMMONIUM PURPURATE $C_8H_4(H_4N)N_5O_6$, or **Murexide**, is easily formed by heating dry alloxantin with $2H_3N$ at 100° C. Thus: $C_8H_4N_4O_7 + 2H_3N =$ **$C_8H_4(H_4N)N_5O_6,OH_2$**. Small square prisms, of green metallic lustre, little soluble in water. **Allantoin** $C_4H_6N_4O_3$, in brilliant prismatic crystals, soluble in 160 parts of cold water. Contained in the allantoic fluid of the fœtal calf.

Artificially by boiling uric acid with lead peroxide and water: $2C_5H_4N_4O_3 + O_2 + 5OH_2 = 2$ UREA $+ 2$ OXALIC ACID $+$ **$C_4H_6N_4O_3$**. **Thionuric acid** $C_4H_5N_3SO_6$, as AMMONIUM THIONURATE is obtained when a solution of ALLOXAN $C_4H_2N_2O_4$ is mixed with a slight excess of $SO(OH)_2$: then ammonia and ammonium carbonate are added, and the whole boiled. When thionuric acid is boiled with water $+ OH_2 = SO_2(OH)_2 +$ **uramil** $C_4H_5N_3O_3$. Then: URAMIL $C_4H_5N_3O_3 +$ ALLOXAN $C_4H_2N_2O_4 +$ AMMONIA $H_3N =$ **murexid** $C_8H_4(H_4N)N_5O_6,OH_2$.

VI. Hexacarbon C_6 group. Hexane C_6H_{14} series.

Hexane C_6H_{14} or **di-propyl**. Occurs as normal $CH_3.(CH_2)_4CH_3$ in petroleum. Boils at 70° C. From normal PROPYL IODIDE by sodium. **Or** by $2ClH + Zn$ on secondary HEXYL IODIDE. **Iso-hexane**, or PROPYL-DIMETHYL-METHANE, boils at 62° C. **Methyl-butyl carbinol** or PRIMARY HEXYL ALCOHOL $C_6H_{13}.OH =$ **$CH_3(CH_2)_4CH_2OH$**. Liquid of strongly aromatic odor. Sp. gr. 0.82: boils at 156.6° C. The essential oil of *Heracleum giganteum* is a mixture of hexyl butyrate and octyl acetate. CAPROIC ALDEHYDE $CH_3(CH_2)_4COH$. **Caproic acid** or PENTYL FORMIC ACID **$CH_3(CH_2)_4COOH$**. The sixth of the fatty series, of which **formic acid** $H.COOH$ is the first. Clear, mobile liquid, of pungent sudorific odor. Sp. gr. 0.895; boils at 205° C. Contained in perspiration; as a glyceride in butter, and largely in cocoanut-oil. Artificially by heating normal **pentyl cyanide** $CH_3(CH_2)_4.CN$ with KOH solution. **Hexene glycol** $C_6H_{12}(OH)_2$ $=$ **$CH_2OH.(CH_2)_4.CH_2OH$**. Boils at 207° C. SECONDARY HEXYL ALCOHOL or METHYL-BUTYL-CARBINOL **$CH_3.C_4H_9.CHOH$**, is a viscid liquid, of pleasant, refreshing odor; boils at 137° C. By ClH, into CHLORIDE, and water. Prepared by treating MANNITE $C_6H_8(OH)_6$ with strong HI, we obtain $6OH_2 + 5I_2 +$ SECONDARY HEXYL IODIDE $C_6H_{13}I$. The latter, with AgOH gives $AgI +$ **$CH_3.C_4H_9.CHOH$**. When oxydized, into METHYL-BUTYL-KETONE $CH_3.CO.C_4H_9$. **Hexene** C_6H_{12} is obtained from this alcohol.

The **hexatomic alcohols** and **ethers** must be included in this group. **Mannite** $C_6H_8(OH)_6$, in four-sided prisms, easily soluble in water and alcohol: not in ether. Melts at 166° C. Made from manna, an exudation from the ash. Also contained in mushrooms, onions, celery, asparagus, and in various sea-weeds. Glucose also by nascent H_2 into mannite. By oxydation with Platinum black, into MANNITIC ACID $CH_2OH(CHOH)_4COOH$; and further by nitric acid into SACCHARIC ACID $(CHOH)_4(COOH)_2$ and OXALIC ACID. By fuming $NO_2(OH)$ into NITRO-MANNITE $C_6H_8(NO_2)_6O_6$. By hydriodic acid into secondary hexyl alcohol. **Dulcite** is isomeric with mannite. A sugar imported from Madagascar. Melts at 182° C. Yields MUCIC ACID by oxydation

with nitric acid. **Sorbite** contains water of crystallization $2[C_6H_8(OH)_6],3OH_2$. Melts at 110° C. None of these sugars ferment with yeast, or reduce alkaline cupric solutions. PINITE and QUERCITE, are sugars isomeric with MANNITAN $C_6H_8O(OH)_4$. **Glucose** $C_6H_{12}O_6$, is the aldehyde of mannite, into which it is changed by nascent hydrogen. DEXTROSE is the common glucose or grape-sugar,—the sugar of fruits. It requires 1.224 parts of water for its solution, and is therefore less sweet than SUCROSE. It crystallizes as $C_6H_{12}O_6,OH_2$ in granular masses. Readily loses this water, and at 170° C. into GLUCOSAN $C_6H_{10}O_5 + OH_2$, which does not ferment, and is scarcely sweet. Solution of dextrose, reduces solution of cupric salts, when rendered alkaline, and with sulphuric acid forms SULPHO-SACCHARIC ACID $C_6H_{12}O_5SO_3$. Reduces also salts of Ag, Hg and Au.—CaO, BaO, and PbO form compounds with dextrose. Unites with NaCl. Browns with KOH. With yeast at 24° C. undergoes vinous fermentation: $C_6H_{12}O_6 = 2CO_2 + 2[C_2H_5(OH)]$. In diabetes abnormally; in the blood, albumin of eggs and in the urine, normally in minute quantities. Artificially, dextrose *prepared* from STARCH $C_{18}H_{30}O_{15}$ by diastase, or boiling with dilute sulphuric acid. First into dextrin and dextrose: $C_{18}H_{30}O_{15} + OH_2 = 2(C_6H_{10}O_5) + C_6H_{12}O_6$. By further OH_2, dextrin into dextrose. **Laevulose** $C_6H_{12}O_6$, in honey and many fruits, with dextrose. Fruit-sugar is a mixture of the two: also called invert sugar. Very sweet, uncrystallizable syrup, very soluble in alcohol. Its calcium compound is solid, and separable from dextrose; then decomposed by CO_2. Also formed by dilute sulphuric acid and heat from sucrose. LAEVULOSAN $C_6H_{10}O_5$ is the anhydride or oxygen ether. From sucrose by heat at 160° C. = DEXTROSE $C_6H_{12}O_6$ + LAEVULOSAN, *which does not ferment.* **Inosite** $C_6H_{12}O_6$, in prisms, resembling Selenite. Not fermentable. In the muscular substance of the heart, and other organs, in beans of various kinds, and in lentils, &c. GALACTOSE $C_6H_{12}O_6$, also resembles dextrose, and is obtained from LACTOSE, by heating with dilute sulphuric acid. GLUCOSIDES contain glucosan; formed by heating for a length of time, glucose with various organic acids, and elimination of water. **Sucrose** $C_{12}H_{22}O_{11}$ is a **di-glucosic alcohol.** $2C_6H_{12}O_6 - H_2O = \mathbf{C_{12}H_{22}O_{11}}$. Chiefly from *Saccharum officinarum.* Also in almonds, nuts, coffee-beans, most sweet fruits, &c. As sugar-candy, in 4-sided, oblique-rhombic prisms, with di-hedral summits. "Syrup" boils at 110° C., but reduced to 65°.5 C. in vacuum-boilers. Melts at 160° C. Barley-sugar is amorphous sucrose. Very sweet, as it requires only one-third of its weight of water for solution. Antiseptic. By long boiling, + H_2O into laevulose; quickly, by dilute acids. SO_4H_2, decomposes sucrose, with separation of carbon. Easily oxydized; hence a reducing agent. Does not

brown with alkalies, nor does its solution reduee cupric salts in presenee of KOH. Heated to 160° C. into DEXTROSE $C_6H_{12}O_6$ and LAEVULOSAN $C_6H_{10}O_5$: at 210° C., into **caramel** $C_{12}H_{18}O_9 + 2H_2O$. By dilute nitric aeid, at 50° C., $+ 3O_2 = H_2O +$ SACCHARIC ACID $(CHOH)_4(COOH)_2$: at a boiling heat into OXALIC ACID $C_2O_2(COOH)_2$ (p. 98). Dissolves CaO, and forms ealcium compounds; also with ClNa. [**Melitose** $C_{12}H_{22}O_{11}.3OH_2$, from the manna of Euealyptus.] **Lactose** $C_{12}H_{22}O_{11},OH_2$, is milk-sugar. From whey, in white, translucent, four-sided prisms of great hardness. Requires five to six times its weight of water for solution: insoluble in aleohol and ether. Right-handed rotation, like dextrose. Reduces eupric salts. By dilute SO_4H_2, into dextrose. Forms a erimson solution with oil of vitriol. With dilute nitrie acid into MUCIC ACID $C_4H_4(OH)_4(COOH)_2$, soluble in 66 parts of boiling water. Gradually ferments with yeast. With cheese or glutin, into **methyl-** or ordinary **lactic acid** $CH_3.CHOH.COOH = C_3H_6O_3$ (p. 103). **Trehalose** $C_{12}H_{22}O_{11},2OH_2$ from Trehala manna. **Mycose** $C_{12}H_{22}O_{11},OH_2$, from ergot of rye, resembles trehalose. Both are very soluble and very sweet.—**Starch** $C_{18}H_{30}O_{15}$, may be regarded as the anhydride or oxygen-ether of a triglucosic alcohol. From $3C_6H_{12}O_6$ *minus* $3OH_2 = C_{18}H_{30}O_{15}$. Starch, fecula or amylum is most abundantly diffused through seeds, roots, tubers, stems, &c. Varieties of stareh. *Sago*, from the pith of a palm. *Tapioca* from *Jatropha Manihot*. *Salep* from *Orchis mascula*. Arrowroot from *Maranta arundinacea*. A very dilute solution of sodium hydroxide is employed in removing the glutin from rice, and leaving the starch. Soft, white, glistening powder, destitute of crystalline strueture. made up of little rounded and flattened grains, upon each of which a series of depressed parallel rings surrounding a central hilum may be traced. Differ in size and shape; largest in potato-starch, smallest in rice. Insoluble in water, alcohol and ether. Heated with water above 60° C., the granules swell, burst and form a gelatinous mass (amidin), preeipitated by ammoniacal lead acetate, by infusion of galls. With free iodine, starch forms a blue compound: the chief test. Heated to 204° C. into DEXTRIN $C_6H_{10}O_5$, which is used as a substitute for gum arabic. When boiled with very dilute sulphuric acid, first by $\mathbf{OH_2}$, starch is ehanged into 2 of DEXTRIN and 1 of DEXTROSE, and the dextrin by further boiling altogether into DEXTROSE $C_6H_{12}O_6$. GLYCOGEN $C_6H_{10}O_5$, is a stareh-like substance obtained from the liver of many animals and from the muscles of fœtal calves. Soluble in water; solution opalescent. Insoluble in alcohol. **Inulin** $C_6H_{10}O_5$, in Inula, Leontodon, Colchicum, Dahlia tubers, &c. Colored brown by iodine. By acids into laevulose. Not precipitated by lead acetate or infusion of galls. **Cellulose** $C_{18}C_{30}O_{15}$,

is the basement-tissue of vegetables. Porous in pith; dense in vegetable ivory. Tasteless, insoluble in water and alcohol, unaffected by boiling water, as will be understood by the remembrance of the nature of linen and cotton, which may be regarded as cellulose. By strong sulphuric acid into dextrin, and by subsequent boiling with water into dextrose; the acid removable by chalk, and filtration from SO_4Ca. Cellulose is not colored by iodine, and is soluble in ammoniated solution of Cupric oxide. By strong NO_2OH, into **pyroxylin** or **guncotton** $C_{18}H_{21}(NO_2)_9O_{15}$, insoluble in mixed alcohol-ether. Another variety $C_{18}H_{22}(NO_2)_8O_{15}$ is soluble in alcohol-ether. Yet another $C_{18}H_{21}(NO_2)_7O_{15}$, is soluble in glacial acetic acid: the two last used in making collodion. Reducing agents replace the hydrogen. **Arabin,** $C_{12}H_{20}O_{10},OH_2$, as in gum arabic, is isomeric with sucrose. Soluble in cold water, it is precipitated by alcohol. White or pale-yellow, non-crystalline, of smooth conchoidal fracture. It is not precipitated by neutral lead acetate. **Mucilage** resembles arabin, but is not precipitated by lead acetate. **Gum tragacanth** is not soluble in water; chiefly composed of bassorin. **Cerasin,** from *Prunus Cerasus*, resembles bassorin. [**Pectose** is contained in the pulp of *unripe* fleshy fruits, fleshy roots, &c. It is insoluble in water, and changed by acids into soluble **Pectin** $C_{32}H_{48}O_{32}$, such as is contained in ripe currants, gooseberries, &c., and causes the formation of jellies. Separable by alcohol from solution.]

To the glucosides belong certain bitter, crystalline substances, diffused through vegetable kingdom, which, by boiling with dilute acids or alkalies $(+ OH_2)$, change into **glucose** and some other substances. **Salicin** $C_{13}H_{18}O_7$. White needles, of bitter taste in bark of Salix, Populus, &c. By SO_4H_2, deep red. By EMULSION, $+ OH_2 =$ GLUCOSE $C_6H_{12}O_6$ + **Saligenin** $C_7H_8O_2$. When distilled with SO_4H_2 and $CrO_3,CrO_2(OK)_2$, it yields SALICYLIC ALDEHYDE $C_6H_4OH.COH$. **Helicin** $C_{13}H_{16}O_7$, crystalline bitter. By dilute NO_2OH upon SALICIN $C_{13}H_{18}O_7$. **Aloin** $C_{17}H_{18}O_7$, yellow needles, the active principle of aloes. **Amygdalin** $C_{20}H_{27}NO_{11},3OH_2$ in white, inodorous, slightly bitter scales. Thus by synaptase or emulsion, a species of diastase: $2C_{20}H_{27}NO_{11} =$ GLUCOSE $C_6H_{12}O_6 + 2CNH + 4OH_2 + 4HCOOH + 4C_6H_5COH$. **Populin** $C_{13}H_{17}(C_7H_5O)O_7$ accompanies **salicin** in bark of the aspen. **Aesculin** $C_{21}H_{24}O_{13}$, crystalline and fluorescent. **Phlorizin** $C_{21}H_{24}O_{10},2OH_2$, silken needles. In root-bark of the cherry, apple, &c. By dilute acids $+ OH_2 =$ GLUCOSE $C_6H_{12}O_6$ + PHLORETIN $C_{15}H_{14}C_5$. **Glycyrrhizin** $C_{24}H_{36}O_9$, uncrystallizable sugar of liquorice. Does not ferment. **Myronic acid** $C_{10}H_{19}NS_2O_{10}$ as POTASSIUM MYRONATE in black mustard-seed. By myrosin, into GLUCOSE $C_6H_{12}O_6$, POTASSIUM HYDROXYL SULPHATE $SO_2(OH)(OK)$ and SULPHOCYANIDE OF ALLYL NCC_3H_5S

(p. 103). **Chitin** $C_9H_{15}NO_6$, forms the elytra and integuments of insects, and the carapaces of crustaceans. By $2H_2O = C_6H_{12}O_6 +$ LACTAMIDE $C_3H_5(H_2N)O_2$.

The benzene-derivates may also be considered under the Hexyl-group. The hydro-carbons of this series C_nH_{2n-6}, the **aromatic group**, are analogous to the paraffin series of the fatty group.

Benzene, Phene or **phenyl hydride** $C_6H_5H = C_6H_6$, a colorless, limpid liquid, of sp. gr. 0.885 and ethereal odor. Boils at 80°.5 C. Solidifies at 0° C. Soluble in alcohol and ether. A great solvent of fats, oils, resins, sulphur, phosphorus, &c. At a bright-red heat, in absence of air, into $H_2 + C_2H_2 +$ DIPHENYL $C_{12}H_{10}$, &c. Is contained in the more volatile portions of coal-tar oil. Also by heating **benzoic acid** $C_6H_5.COOH$ with CaO $= CO(O_2Ca) + \mathbf{C_6H_6}$. Unites with $3Cl_2$ to $C_6H_6Cl_6$, a crystalline body. Also with 3ClOH to $C_6H_6(ClOH)_3$: by potassium hydroxide into $3ClK +$ **phenose** $C_6H_{12}O_6$. **Mono-chlorbenzene** C_6H_5Cl, liquid of 1.128 sp. gr. By Cl_5P upon PHENOL C_6H_5OH. **Cyano-benzene** C_6H_5CN is PHENYL CYANIDE, an oily liquid. Also "benzo-nitrile," and obtained by dehydration of AMMONIUM BENZOATE $C_6H_5.\mathbf{COOH_4}N$. **Nitro-benzene** $C_6H_5(NO_2)$, yellow liquid of aromatic odor. Substitute for oil of bitter almonds in perfumery. **Di-nitro-benzene** $C_6H_4(NO_2)_2$, in long rhombic prisms. Separates, on cooling, from alcoholic solution of both. **Amido-benzene** or **Phenyl-amin** is **Anilin** $C_6H_5(H_2N)$. Colorless, oily liquid, of sp. gr. 1.036; boils at 184°.5 C. Soluble in 31 parts of cold water. Browns on exposure. Stains deal yellow. With Cl_2OCa, in aqueous solution, violet. Powerful base. *Prep.* *a.* by boiling indigo with KOH solution: $C_8H_5NO + OH_2 + 4KOH = 2CO(OK)_2 + \mathbf{C_6H_5(H_2N)} + 2H_2$. The name from *Indigofera anil.* *b.* On the large scale by reducing NITRO-BENZENE $C_6H_5.NO_2$. Thus: $C_6H_5NO_2 + 3H_2 = 2OH_2 + \mathbf{C_6H_5, H_2N}$. *c.* by heating PHENOL $C_6H_5.OH$, in sealed tubes with $H_3N = OH_2 + \mathbf{C_6H_5.H_2N}$. — **Di-phenylamin** $(C_6H_5)_2HN$. A weak base: crystalline. By heating phenylamin hydrochloride with phenylamin. **Tri-phenylamin** $(C_6H_5)_3N$.— The **anilides contain acid radicles.** Thus: **acetanilide** $C_6H_5.H_2N.C_2H_3O$. Obtained by heating anilin with acetic acid. **Phenyl-carbamide** $CO(H_2N)(C_6H_5HN)$ is phenyl-urea. By passing cyanic acid vapor into anilin. **Phenyl-phosphine** $C_6H_5H_2P$. **Benzene-sulphonic acid** $C_6H_5.SO_3H$, by heating benzene with oil of vitriol.

1. **Phenol** or **phenyl alcohol** $C_6H_5.OH$, is commonly known as carbolic acid. It is a monatomic alcohol. Crystallizes in colorless prisms, of sp. gr. 1.066. Melts at 40° C.: boils at 181°.5 C. Burning taste, antiseptic, poisonous. Soluble in 15 of water: colored violet by Cl_6Fe_2, and stains deal of a blue color. Precipitated by aqueous Bromine. With oil of vitriol,

PHENOLSULPHONIC ACID $C_6H_4(OH)SO_3H$. Obtained from the acid portion of coal-tar-oil. *Also* by heating SALICYLIC ACID $C_6H_4.OH.COOH = CO_2 + \mathbf{C_6H_5OH}$. *Also* from phenylamin by $NO.OH = N_2 + OH_2 + \mathbf{C_6H_5.OH}$. POTASSIUM PHENATE $C_6H_5.OK$. **Phenyl hydrosulphide** $C_6H_5.SH$, is a colorless, mobile, malodorous liquid, of sp. gr. 1.078. By P_2S_5 on $C_6H_5.OH$. **Phenyl sulphide** $(C_6H_5)_2S$, a colorless liquid, of sp. gr. 1.12. [**Nitro-phenol** $C_6H_4.NO_2.OH$, in large yellow prisms. **Di-nitro-phenol** $C_6H_3(NO_2)_2.OH$, in colorless plates.] **Tri-nitro-phenol** $C_6H_2(NO_2)_3.OH$, is known as *picric acid* and *carbazotic acid*. In yellow laminæ, of intensely bitter taste. Sparingly soluble. Yellow dye for silk and wool. A test for K. Prepared from phenol by action of NO_2OH. [2. **Pyro-catechin** $C_6H_4(OH)_2$, is a diatomic phenol. In short square prisms, readily soluble in water. By heating methyl-pyrocatechin with $IH = ICH_3 + C_6H_4(OH)_2$. **Hydro-quinone** $C_6H_4(OH)_2$, colorless, rhombic prisms. **Quinone** $C_6H_4O_2$, golden-yellow prisms. **Tetrachloro-quinone** is Chloranil $C_6Cl_4O_2$.] 3. **Pyrogallol** $C_6H_3(OH)_3$ or **pyro-gallic acid**, is a **tri-atomic phenol**. Long, flattened prisms, very soluble. Melts at 115° C. At 250° C., with loss of OH_2 into metagallic acid $C_6H_4O_2$. Its solution in KOH absorbs O, browns, and may be employed for estimating O in air. Reduces salts of Au, Ag and Hg. *Prep.* by heat on **gallic acid** $C_6H_2(OH)_3COOH$. **Benzyl alcohol** $C_6H_5.CH_2OH$, is a **normal aromatic alcohol**. Colorless, oily liquid, insoluble in water. Boils at 207° C. By Platinum black into BENZOIC ALDEHYDE C_6H_5 COH, and by aqueous chromic acid into BENZOIC ACID $C_6H_5.CO(OH)$. Benzoic ether is contained in Balsams of Peru and Tolu. *Prep. a.* from **benzaldehyde** by H_2. *b.* from BENZYL ACETATE $C_6H_5.CH_2.OC_2H_3O + KOH = C_2H_3O.OK +$ BENZYL ALCOHOL $\mathbf{C_6H_5.CH_2OH}$.—**Benzoic aldehyde** $C_6H_5.COH$, known as "bitter-almond oil." Colorless liquid, of agreeable odor. Sp. gr. 1.05; boils at 180° C. Soluble in 30 parts of water. Absorbs O and becomes changed into BENZOIC ACID $C_6H_5.COOH$. Heated with KOH, H_2 set free, and potassium benzoate formed. With alkaline-hydroxyl sulphites, forms crystalline compounds. With sodium amalgam and water into BENZYL ALCOHOL $C_6H_5CH_2OH$. With Cl_5P into BENZAL CHLORIDE $C_6H_5.CHCl_2$. By H_3N into hydrobenzamide, a neutral body, and this by boiling KOH into an isomeric basic compound **amarine** $(C_7H_6)_3N_2$. All aromatic aldehydes act similarly, and thus distinguished from the fatty aldehydes. **Salicylic aldehyde** $C_6H_4(OH).COH$, in flowers of Oil of meadow-sweet. Colorless, fragrant oil, of sp. gr. 1.172. Somewhat soluble in water, and gives violet color with ferric salts. Heated with KOH into H_2 + POTASSIUM SALICYLATE $C_6H_4.OH.COOK$. By nascent H_2 into SALIGENIN. *Prep.* by oxydizing SALIGENIN $C_6H_4.OH.CH_2OH$, or its **glucosides**, salicin

and populin (p. 111). Also by chloroform on alkaline solution of phenol. $C_6H_5.OH + CHCl_3 + OH_2 = 3ClH + \mathbf{C_6H_4.OH.COH}$. **Benzoic acid** $C_6H_5.COOH$. Light, flexible needles. Melts at 120° C; sublimes at 145° C. Soluble in 200 of cold, and 15 of boiling water. Basic ferric benzoate is decomposed by ClH, leaving shiny crystals of benzoic acid undissolved in the yellow ferric chloride solution. Calcium benzoate by heat, gives BENZOPHENONE C_6H_5 CO C_6H_5, the ketone of benzoic acid, and $CO(O_2Ca)$. *Prep. a.* by heating gum benzoin, benzoic acid sublimes. *b.* by OH_2 on BENZOYL CHLORIDE C_6H_5COCl. *c.* by boiling the nitrile with acids or alkalies; $C_6H_5CN + 2OH_2 = H_3N + \mathbf{C_6H_5.COOH}$. *d.* by oxydizing BENZYL ALCOHOL: $C_6H_5.CH_2OH + O_2 = OH_2 + \mathbf{C_6H_5.COOH}$. *e.* by oxydizing BENZALDEHYDE $C_6H_5.COH + O = \mathbf{C_6H_5.COOH}$. *f.* from BROMOBENZENE by $Na_2 + CO_2 = BrNa + \mathbf{C_6H_5\ COONa}$. **Benzoyl chloride** $\mathbf{C_6H_5COCl}$, colorless liquid of suffocating odor. By Cl_5P upon benzoic acid. BENZOYL CYANIDE C_6H_5COCN, by distilling the chloride with CNK. In large scales. **Benzoic oxide** $(C_7H_5O)_2O$, in oblique prisms, slowly by boiling water into benzoic acid. $C_6H_5COCl + C_6H_5CO.OK = ClK + \mathbf{(C_7H_5O)_2O}$. **Thiobenzoic acid** $C_6H_5.CO.SH$. **Benzamide** $C_6H_5.CO.H_2N$, by aqueous H_3N upon benzoyl chloride. **Amido-benzoic acid** $C_6H_4(H_2N)COOH$, by reduction of **nitro-benzoic acid** $C_6H_4(NO_2)COOH$ with Sn + 2ClH.—**Benzamid-acetic acid** or **hippuric acid** $CH_2.\mathbf{C_7H_5O}.HN.COOH = C_9H_9NO_3$ Or "benzoyl-glycocin." Occurs in the urine of cows, horses, &c. By evaporating fresh cow's urine, to which lime has been added, and adding ClH to the concentrated liquor, hippuric acid crystallizes on cooling. When benzoic acid is taken internally, it is found in the urine as hippuric acid. Rhombic prisms, soluble in 600 of cold water. Acid, bitter, fusible: leaves a coaly residue. By boiling with ClH, assimilation of OH_2, into BENZOIC ACID $\mathbf{C_7H_5O.OH}$ + AMIDACETIC or GLYCOCIN $\mathbf{CH_2(H_2N)COOH}$. Hippurate of ferric, cream-colored. Heated with HOK, gives off H_3N and benzene. Mineral acids separate hippuric acid. NOOH converts hippuric acid into $OH_2 + N_2$ + BENZO-GLYCOLLIC ACID $C_9H_8O_4$: and boiling water $(+ OH_2)$ changes benzo-glycollic acid into BENZOIC ACID $C_7H_5O.OH$ and GLYCOLLIC ACID $CH_2.OH\ COOH$. *Prep.* by $2\mathbf{C_7H_5OCl}$ + ZINC-GLYCOCIN $(CH_2.H_2N.COO)_2Zn = Cl_2Zn$ + 2 BENZAMID-ACETIC ACID.

Tyrosin $C_9H_{11}NO_3$ has the composition of OXY-PHENYL-AMIDO-PROPIONIC ACID $C_6H_4.OH.C_2H_3(H_2N).COOH$. In old cheese, τυρός. In the spleen, pancreas and liver. By boiling horn with dilute sulphuric acid, neutralizing with CaO, and precipitation by acetic acid. In slender needles, soluble in 150 of hot water; insoluble in ether. Unites with ClH; its sulpho-acid colored violet by ferric salts. **Toluene**, C_7H_8, homologous with benzene,

is **methyl-benzene** $C_6H_5.CH_3$. Together with benzene in light coal-tar-oil. Limpid liquid, of sp. gr. 0.88. With oxydizing agents yields benzoic acid. Artificially: $C_6H_5Br + CH_3I + Na_2 = BrNa + INa + C_6H_5.CH_3 = C_7H_8$. Also by nascent $C_6H_6 + CH_4 = H_2 + C_7H_8$. **Chloro-toluene** $C_6H_4Cl.CH_3$. TOLUIDIN $C_6H_4.H_2N.CH_3$ is homologous with phenyl-amin. Commercial anilin always contains toluidin, and the formation of ROSANILIN $C_{20}H_{17}N_3$ can be accounted for by the following equation: $C_6H_5.H_2N + 2C_7H_7.H_2N = 4H_2 +$ **rosanilin** $C_{20}H_{17}N_3$. Anilin reds are salts of rosanilin: the latter being colorless. Anilin-blue is HYDROCHLORIDE of TRIPHENYL-ROSANILIN $C_{20}H_{14}(C_6H_5)_3N_3ClH$. By heating rosanilin with ethyl iodide, we obtain Hofmann's violet, HYDRIODIDE of TRIETHYL-ROSANILIN $C_{20}H_{14}(C_2H_5)_3N_3.IH$. Anilin-green is an aldehyde-green. Nitrous acid $3(NO.OH)$ converts rosanilin into $3N_2 + 3OH_2 +$ **aurin** $C_{20}H_{14}O_3$. **Anisol** is methyl phenate $C_7H_8O = C_6H_5(OCH_3)$. Colorless, mobile liquid, of aromatic odor. Boils at 152° C. **Cresol** is **tolyl alcohol** $C_6H_4.CH_3.OH$. Occurs together with phenol in coal- and wood-tar. Separated by fractional distillation. By long heating with KOH into POTASSIUM SALICYLATE. **Xylyl alcohol** C_8H_9OH or $C_6H_4.CH_3.CH_2OH$, is the homologue of benzyl alcohol. It is obtained from the aldehyde. Needles, sparingly soluble. **Toluic aldehyde** $C_6H_4.CH_3.COH$. Oily liquid, with odor of pepper. **Salicylic aldehyde** $C_6H_4.OH.COH$. **Salicylic acid** $C_6H_4.OH.COOH$ is ORTHO-OXY-BENZOIC ACID $C_7H_6O_3$. In the flowers of *Spiræa ulmaria*, and as methyl salicylate in oil of winter-green. Little soluble in cold water, crystallizing in minute needles from boiling water. It melts at 155° C., and is resolved by heat into CO_2 and PHENOL $C_6H_5.OH$. Gives deep violet color to ferric salts. Good antiseptic. *Prep.* by heating SODIUM with PHENOL C_6H_5O and $CO_2 =$ HYDROGEN free + SODIUM SALICYLATE $C_6H_4.OH.COONa$. Also by oxydation of salicylic aldehyde. Also by NO.OH upon AMIDO-BENZOIC ACID $C_6H_4(H_2N).COOH = OH_2 + N_2 +$ SALICYLIC ACID $C_6H_4.OH.COOH$. OXY-SALICYLIC ACID $C_6H_3.(OH)_2COOH$, in shining needles. **Gallic acid** or **di-oxy-salicylic acid** $C_6H_2(OH)_3COOH$ in gall-nuts (*Quercus infectoria*), tea, sumach, divi-divi, &c. By boiling GALLO-TANNIC ACID with acids or alkalies: $+ OH_2 = 2$ GALLIC ACID $C_7H_6O_5$. Mono-basic; tetratomic. With OH_2, in silken needles, soluble in 100 of cold and 3 of boiling water. Melts at 200° C., and by further heat into CO_2 and **pyro-gallol** $C_6H_3(OH)_3$. Reduces salts of Ag and Au. Gives blue-black precipitate with Cl_6Fe_2. May be obtained from DI-IODO-SALICYLIC ACID with $CO(ONa)_2$.—**Gallo-tannic acid** or **tannin** $C_{14}H_{10}O_9$ is di-gallic acid minus OH_2. $C_6H_2(OH)_3.CO.O.C_6H_2(OH)_2.COOH$. In nut-galls, sumach, &c. From nut-galls by aqueous ether: tannin in the water, and the gallic acid in the ether. On evaporation,

a yellowish powder, very soluble in water. Astringent; bitter. Reddens litmus. Precipitates gelatin, albumin, many alkaloids, &c. Ferric tannate, a bluish-black precipitate, is the basis of common ink. Decomposes at 250° C., with formation of pyrogallol. By dilute acids + OH_2 into 2 mols. of gallic acid. **Kinic acid** $C_6H_7(OH)_4COOH$, is mono-basic, pentatomic. In cinchona bark. Colorless prisms, easily soluble. By heating with 2IH = $4OH_2 + I_2$ + benzoic acid. **Dimethyl-benzene** or **xylene** $C_8H_{10} = C_6H_4.(CH_3)_2$ is the homologue of BENZENE C_6H_6 and TOLUENE C_7H_8. Colorless, volatile liquid. Several isomeric modifications. **Dimethyl anilin** $C_6H_5(CH_3)_2N$. Boils at 192° C. **Dimethyl phenol** $C_8H_{10}O = C_8H_9.OH = \mathbf{C_6H_3.(CH_3)_2.OH}$. Also, XYLENOL. **Phenyl-propyl alcohol** $C_9H_{11}OH = C_6H_5.(CH_2)_3.OH$. By nascent hydrogen on CINNAMIC ALCOHOL C_9H_9OH. **Phthalic aldehyde** $C_8H_6O_2 = C_6H_4(COH)_2$. From PHTHALYL CHLORIDE $C_6H_4(COCl)_2$ by nascent H. In colorless tables. **Phthalic acid** $C_6H_4(COOH)_2$, in prisms, little soluble in cold water. Melts at 185° C. By heat into water and PHTHALIC ANHYDRIDE $C_6H_4(CO)_2O$. By action of $4O_2$ upon **napththalene** $C_{10}H_8$ = OXALIC ACID + PHTHALIC ACID. When $\mathbf{C_6H_4(COOH)_2}$ is heated with excess of Calcium hydroxide, we obtain BENZENE C_6H_6 and $2[CO(O_2Ca)]$; but when $2[C_6H_4(COOH)_2]$ are heated with $(OH)_2Ca$, CALCIUM BENZOATE $(C_6H_5COO)_2Ca$ results, together with $2OH_2 + 2CO_2$. [**Mellitic acid** $C_6(COOH)_6$, in colorless needles, fusible; very stable. Mellite or "Honey-stone" is mellitate of aluminum. **Rhodizonic acid** $C_3O_2H_2(COOH)_2$, formed by the action of water upon $C_3O_3K_3$. **Croconic acid** $C_5H_2O_5$ by action of boiling on solution of potassium rhodizonate.] **Citric acid** $C_6H_8O_7 = C_3H_4(OH)(COOH)_3$, crystallizes with OH_2 in trimetric prisms from a cold solution. Very soluble, of pleasant sour taste. Tetratomic, tribasic. Prevents precipitation of ferric by ammonia. If mixed with tartaric acid, in solution detected by potassium acetate. On boiling citric acid with lime-water in slight excess, calcium citrate is precipitated white, insoluble in KOH. With a ferment of putrid flesh, yields butyric acid chiefly, and succinic acid. Gently heated with SO_4H_2, gives off torrents of CO. Heated with POTASSIUM HYDROXIDE: 4KOH + citric acid $= C_2O_2(OK)_2 + 2(CH_3.COOK) + 3OH_2$. Salts of Ba, Sr, Ca, Pb and Ag insoluble. Found in lemon- and lime-juice. Clear liquor neutralized with chalk, and the calcium citrate decomposed by SO_4H_2.

VII. **Heptane series.** Normal **heptane** $C_7H_{16} = CH_3.(CH_2)_5.CH_3$, liquid of sp. gr. 0.712, is contained in petroleums. **Heptyl alcohol** or **œnanthylic alcohol** $CH_3.(CH_2)_5CH_2OH$, is a colorless, oily liquid. From heptyl aldehyde $CH_3.(CH_2)_5COH$ by moist sodium amalgam. **Œnanthylic acid** $C_7H_{14}O_2$ is the seventh of the fatty acids (p. 85).

VIII. **Octane series.** Normal **octane** $C_8H_{18} = CH_3(CH_2)_6CH_3$,

boils at 124° C. **Octyl alcohol** $C_7H_{15}.CH_2OH$, a colorless oily liquid, of sp. gr. 0.830. Is contained in the seed of *Heracleum sphondylium*, both uncombined and as octyl acetate, and as octyl butyrate in the seeds of *Pastinaca sativa*. Artificially from RICINOLEIC ACID $C_{18}H_{34}O_3 + 2HOK$ = POTASSIUM SEBATE $C_{10}H_{16}O_2(OK)_2 + H_2$ + **octyl alcohol** $C_7H_{15}.CH_2OH$. CAPRYLIC ACID $C_7H_{15}.COOH$, of faint, unpleasant odor, is found as glyceride in butter, and in cocoa-nut-oil.

IX. **Nonane series.** Normal **nonane** $C_9H_{20} = CH_3(CH_2)_7CH_3$, boils at 136° C. Sp. gr. 0.741. **Nonyl alcohol** $C_8H_{17}.CH_2OH$, boils at 200° C.

X. **Decane series.** Normal **decane** $C_{10}H_{22} = CH_3(CH_2)_8CH_3$, of sp. gr. 0.757, boils at 160° C. **Decyl alcohol** $C_{10}H_{21}OH = C_9H_{19}.CH_2OH$ boils at 210° C. **Rutic or capric acid** $C_9H_{19}COOH$, as a glyceride in butter and in cocoa-nut-oil. Also from amyl rutate in the fousel oil of the Scotch distilleries. Crystalline.

XI. **Endecane series. Endecane** $C_{11}H_{24}$. XII. **Dodecane series. Dodecane** $C_{12}H_{26}$. LAURIC ACID $C_{11}H_{23}.COOH$, from alcohol, in silken needles. As a glyceride in fat of *Laurus nobilis* and of Pichurim beans. By saponification with potassium hydroxide, and decomposition of the soap with tartaric acid. XIII. **Tridecane series. Tridecane** $C_{13}H_{28}$. XIV. **Tetradecane series. Tetradecane** $C_{14}H_{30}$. MYRISTIC ACID $C_{13}H_{27}.COOH$, in white, lustrous laminæ, which melt at 53°.8 C. Very soluble in hot alcohol. As a glyceride, MYRISTIN $(C_{14}H_{27}O)_3O_3C_3H_5$ in nutmeg-butter and in Otoba fat. XV. **Pentadecane series. Pentadecane** $C_{15}H_{32}$. XVI. **Hexdecane series. Hexdecane** $C_{16}H_{34}$. **Hexdecyl alcohol** $C_{16}H_{33}.OH = C_{15}H_{31}.CH_2OH$. Is **ethal.** As obtained from spermaceti found in cavities in the head of *Physeter macrocephalus*. It consists of CETYL or HEXDECYL PALMITATE $C_{16}H_{31}O.OC_{16}H_{33}$: when fused with KOH = POTASSIUM PALMITATE $C_{16}H_{31}O.OK$ + CETYL ALCOHOL $\mathbf{C_{16}H_{33}OH}$. White crystalline mass, melts at 50° C. Tasteless and insoluble. When heated with KOH = $2H_2$ + POTASSIUM PALMITATE $C_{16}H_{31}O.OK$. **Palmitic acid** $C_{16}H_{32}O_2 = C_{15}H_{31}.COOH$, is the 16th of the fatty acid series. Occurs as a glyceride in many fats. Most largely in palm-oil from *Elais guianensis*, in Chinese tallow, and Japan wax, as **tri-palmitin** $(C_{16}H_{31}O.O)_3.C_3H_5$. Also as cetyl palmitate (spermaceti). Artificially by melting OLEIC ACID $C_{18}H_{34}O_2$ (p. 103) with $2KOH = H_2 + CH_3.COOK + C_{16}H_{31}O.OK$. Soluble in boiling alcohol. Melts at 620° C. May be distilled. MONO- DI- and TRI-PALMITIN.

XVII. **Margaric acid** $C_{17}H_{33}.OH$, was supposed to be intermediate between palmitic and stearic acids. As MARGARATE OF POTASSIUM $C_{17}H_{33}O.OK + NH_3$ by action of CETYL CYANIDE $CNC_{16}H_{33} + KOH + OH_2$. XVIII. **Stearic acid** $C_{18}H_{35}O.OH$, in nacreous laminæ, of acid reaction. Melts at 69° C. TRI-

STEARIN $(C_{18}H_{35}O.O)_3C_3H_5$, a glyceride in most solid fats, as in beef and mutton-suet. **Soaps** consist of mixtures of sodium (or potassium) palmitates, stearates, oleates, &c. They are made by saponifying palm-oil, tallow, &c. Sodium-soaps are *hard;* potassium soaps *soft,* and contain great excess of alkali. XX. **Arachidic acid** $C_{20}H_{39}O.OH$, in small scales, by saponifying the oil of *Arachis hypogæa.* XXII. **Behenic acid** $C_{22}H_{43}O.OH$, melts at 76° C. By saponifying the oil from the fruit of *Moringa Nux Behen.* XXVII. **Cerotyl alcohol** $C_{27}H_{55}OH = C_{26}H_{53}.CH_2OH$. As purified by ether, a wax-like substance, melting at 97° C. Chinese wax is **ceryl cerotate** $C_{27}H_{53}O.OC_{27}H_{55}$. When heated with KOH = POTASSIUM CEROTATE $C_{27}H_{53}O.OK$ + **cerotyl alcohol.** CEROTIC ACID $C_{27}H_{53}O.OH$, is the chief constituent of **cerin,** the portion of bees-wax which is soluble in boiling alcohol, and is obtainable by fusing ceryl cerotate, which melts at 82° C., with KOH, and decomposing with an acid. Melts at 78° C., and distils. XXX. **Myricyl alcohol** $C_{30}H_{61}.OH = C_{29}H_{59}.CH_2OH$, of silken lustre, is the highest known member of the series. **Myricin, or myricyl palmitate** $C_{16}H_{31}O.OC_{30}H_{61}$, is that portion of bees-wax which is insoluble in boiling alcohol. By fusion with KOH, into potassium palmitate and **myricyl alcohol.** MELISSIC ACID, $C_{30}H_{59}O.OH$, melts at 89° C. The highest known member of the fatty series, commencing with FORMIC ACID H.COOH (p. 85). Obtained by heating myricyl alcohol with KOH = $2H_2$ + POTASSIUM MELISSATE $C_{30}H_{59}O.OK$. Decomposed by acids.

Naphthalene group. **Naphthalene** $C_{10}H_8$, in large, colorless brilliant crystalline plates, with odor reminding of narcissus. Melts at 79°.2 C.: boils at 218° C. Burns with red, sooty flame. Soluble in alcohol and ether. Forms additive compounds with Cl, Br, &c. Contained in last portion of oily product obtained from coal-tar. Also produced by decomposition of benzene, toluene, &c. Thus: $4C_7H_8 = 3C_6H_6 + 3H_2 + \mathbf{C_{10}H_8}$. NITRO-NAPHTHALENE $C_{10}H_7NO_2$. NAPHTHYLAMIN $C_{10}H_7(H_2N)$, in needles. NAPHTHALENE-SULPHONIC ACID $C_{10}H_7SO_3H$, crystalline, deliquescent. NAPHTHOL $C_{10}H_7.OH$, colorless prisms; violet with chloride of lime. NAPHTHOQUINONE $C_{10}H_6O_2$, in large, sulphur-yellow tables.

Phenanthrene group. **Phenanthrene** $C_{14}H_{10}$, in colorless, lustrous laminæ. Contained in the portion of coal-tar, which boils between 320° and 360° C. **Anthracene** $C_{14}H_{10}$, in colorless tables, little soluble in alcohol and ether. Melts at 213° C. and distils above 360° C. Both phenanthrene and anthracene contain benzene residues; $C_6H_4.CH.CH.C_6H_4$. **Di-bromanthracene** $C_{14}H_8Br_2$ in golden-yellow needles. By the action of Bromine

on anthracene in CS_2. **Anthrol** $C_{14}H_9.OH$. **Anthraquinone** $C_{14}H_8O_2 = C_6H_4.CO.CO.C_6H_4$, in shiny, yellow needles. Sublimes. Not reduced by $SO(OH)_2$. By oxydation of anthracene. **Di-bromanthraquinone** $C_{14}H_6Br_2O_2$. In yellow needles. Obtained by heating anthraquinone with Bromine. By heating with 2KOH at 150° C., into **alizarin** $C_{14}H_6(OH)_2O_2$. **Anthraquinone-sulphonic acid** $C_{14}H_7O_2SO_3H$, and $C_{14}H_6O_2(SO_3H)_2$, by heating anthraquinone with $SO_2(OH)_2$ at 255° C. **Alizarin** $C_{14}H_6(OH)_2O_2$, in orange-colored needles, forming purple solution with alkalies. Aluminum and tin salts throw down red precipitates of madder-lakes. Alizarin, from the red coloring matter of *Rubia tinctorum;* contains RUBERYTHRIC ACID $C_{26}H_{28}O_{14}$, which by water (+ $2OH_2$) is resolved into 2 DEXTROSE and **alizarin** or **garancin**. Now prepared artificially as above, or cheaper, from $C_{14}H_6O_2(SO_3H)_2$ by fusion with KOH, solution in water, and precipitation of the alizarin by ClH. **Purpurin** $C_{14}H_5(OH)_3O_2$ occurs in old madder-roots together with alizarin. Like alizarin, it is reduced to anthracene, by heating with zinc-dust.

Destructive distillation. Among the products of the distillation of wood and resins must be mentioned **Kreasote** $C_8H_{10}O_2$. Sp. gr. 1.057. It is to kreasote that wood-smoke owes its antiseptic properties. It is contained in the heavier portions of the oil obtained from wood-tar. It is a colorless, oily liquid, which boils at 203° C. Easily inflamed; burns with a smoky flame. Of pungent odor and burning taste. Little soluble in water; very soluble in acetic acid, alcohol and ether. Coagulates albumin (p. 126) and is the best antiseptic. PHENOL or CARBOLIC ACID C_6H_5OH, is the common substitute for genuine kreasote.

Terpenes and **Camphors. Oil of turpentine** $C_{10}H_{16}$, a colorless, mobile liquid, of aromatic odor, insoluble in water, but soluble in absolute alcohol, ether, benzene and carbonic sulphide. A solvent of phosphorus, sulphur, iodine, bromine, oils, resins (varnishes). Many varieties: isomeric and polymeric. In conifers generally. Forms HYDRATES; $C_{10}H_{16},2OH_2$, and $C_{10}H_{16},3OH_2$. By repeated distillation with a little sulphuric acid, into TEREBENE $C_{10}H_{16}$, boiling at 160° C., and COLOPHENE $C_{20}H_{32}$, boiling at a high temperature. Inflames with Chlorine. Unites with 2ClH. CYMENE or METHYL-PROPYL-BENZENE $C_6H_4(CH_3)(C_3H_7)$, is made from turpentine, showing the latter to be a hydride of cumene. By oxydation, turpentine yields acids: formic, acetic, butyric, oxalic, TEREBIC $C_7H_{10}O_4$, TOLUIC $C_6H_4(CH_3)COOH$, and TEREPHTHALIC $C_6H_4(COOH)_2$. **Essential oils.** Either hydrocarbons isomeric or polymeric with oil of turpentine, or of a mixture of these with compounds of C, H and O. **Oil of**

lemons, from the rind of the fruit of *Citrus limonum*, consists chiefly of CITRENE $C_{10}H_{16}$. Similar oils from *Oils of Neroli, Bergamot, Citron, Lime, Orange, &c. Thyme, Valerian, Chamomile, Juniper, &c. Oils of Capivi* and *Cubebs*, polymeric: $C_{20}H_{32}$. Mixed with a terpene, we have valeric acid in *oil of Valerian*, pelargonic acid in *oil of Pelargonium*, EUODIC ALDEHYDE $C_{10}H_{21}COH$ in *oil of Ruta. Some volatile oils* consist of *aldehydes*, as oils of Bitter Almonds, Cinnamon and Cassia. They are all soluble in alcohol and ether, and produce a greasy stain upon paper, disappearing when heated. **Elæoptene** is the liquid, and **stearoptene** the solid portion of an essential oil. None of these oils saponify. **Camphors** contain 10 atoms of carbon. **Laurel camphor** $C_{10}H_{16}O$, a colorless, translucent mass of sp. gr. 0 985. Melts at 175° C., and sublimes at 204° C. Readily soluble in alcohol (tincture). By heating with P_2O_5, into **cumene** $C_{10}H_{14} + OH_2$. In *Laurus Camphora.* Also artificially, as from turpentine, by $Mn_2O_6(OK)_2$. The essential oils of Lavender, Marjoram, Rosemary and Sage contain camphor. **Absinthol** $C_{10}H_{16}O$, from *Artemisia Absinthium* is a liquid camphor. CAMPHORIC ACID $C_8H_{14}(COOH)_2$, in colorless laminæ. By continued boiling of camphor with nitric acid. **Borneo-camphor** $C_{10}H_{18}O$, melts at 108° C., and boils at 212° C. It is an alcohol $C_{10}H_{17}OH$, yielding compound ethers. Obtained artificially by heating laurel camphor with sodium (SODIUM BORNEOL $C_{10}H_{17}.ONa$), or alcoholic HOK. Occurs in *Dryabalanops Camphora.* **Menthol** $C_{10}H_{19}OH$, in oil of *Mentha piperita*, occurs together with a terpene.

Resins and Balsams. COLOPHONY or COMMON ROSIN consists principally of **sylvic acid** $C_{20}H_{30}O_2$. It is monobasic, and crystallizes from alcohol in laminæ. LAC is harder than resin, and known as stick- seed- and shel-lac. Copal, Mastic, Sandarac, Dammar, and Dragon's blood are also resins. Amber is a fossil resin.—CAOUTCHOUC is the dried milky juice of species of Ficus, Euphorbia and other trees. Soluble in petroleum, benzene, &c. Little affected by chemicals. By destructive distillation yields two polymeric bodies: **Isoprene** C_5H_8, and **Caoutchin** $C_{10}H_{16}$. With Sulphur, Caoutchouc gives vulcanized India Rubber, and Ebonite. GUTTA PERCHA, from *Isonandra Gutta*, is harder than caoutchouc, but very similar. A good insulator of electricity. By destructive distillation yields ISOPRENE, CAOUTCHIN and HEVEENE, polymeric hydrocarbons. **Balsams** are mixtures of resins with volatile oils.

Coloring matters. Indigotin $C_{16}H_{10}N_2O_2$, in dark-blue needles, may be obtained by subliming commercial indigo. It does not exist in *Indigofera Anil* ready formed, but as a GLUCOSIDE $C_{26}H_{31}NO_{17}$, which, by boiling with dilute acids, yields INDIGLUCIN $C_6H_{10}O_6$ and INDIGOTIN $C_{16}H_{10}N_2O_2$. Thus; $2C_{26}H_{31}NO_{17}$

$+ 4OH_2 = 6$ indigluein + **indigotin.** **Indigo-white** $C_{16}H_{12}N_2O_2$ is changed into indigotin by the air or oxydizing agents. **Indigo-sulphonic acid** $C_{16}H_9N_2O_2,SO_3H$, by heating indigo with sulphuric acid. **Isatin** $C_8H_5NO_2$, in yellowish-red prisms, by heating indigo with nitric acid. *See* **Phenyl-amin** $C_6H_5.H_2N$, p. 112. Indigo related to benzene group (p. 112). **Carthamin** $C_{14}H_{16}O_7$, as a dark-red powder used for dyeing silk, is obtained from the petals of *Carthamus tinctorius.* **Alizarin** $C_{14}H_6(OH)_2O_2$ has been already described at p. 119. **Hæmatoxylin** $C_{16}H_{11}O_6$, $3OH_2$ in Hæmatoxylon. Pale-yellow prisms. **Carminic acid** $C_{17}H_{18}O_{10}$, in *Coccus Cacti* most largely, and in the flowers of *Monarda didyma.* Fine red powder, soluble in water and alcohol. Di-basic. **Brazilin** $C_{22}H_{18}O_7$, in small yellow prisms, crimson by alkalies. **Curcumin** $C_{10}H_{10}O_3$, in turmeric. Orange crystals, browned by alkalies. **Euxanthic acid** $C_{19}H_{16}O_{10}$, in Purree or Indian Yellow, as magnesium euxanthate. Shiny, yellow prisms. **Chlorophyll** is leaf-green. Soluble in alcohol and in ClH.

Alkaloids.

They are all derivatives of ammonia. The **monamines**, derived from a single molecule of ammonia, may contain one, two or three univalent alcohol-radicles in exchange for 1, 2, or 3 atoms of Hydrogen: **primary, secondary,** and **tertiary.** They expel ammonia from its salts, when heated with them, and form double salts with platinic chloride, Auric chloride, &c. They can also replace hydrogen in the ammonium of alums. PRIMARY AMINES, into corresponding alcohols by NO.OH. Thus: $CH_3(H_2N) + NO.OH = OH_2 + N_2 + CH_3.OH$. Thus, we have a means of passing from a lower into a higher alcohol series. **Ethenyl nitrile** $C_2H_3N + 2H_2 =$ **ethylamin** $(CH_2CH_3)H_2N$, and ethylamin $+ NO.OH = OH_2 + N_2 +$ $\mathbf{CH_2CH_3OH}$. SECONDARY AMINES, by NO.OH into WATER, and nitroso-compounds. Thus: **di-methylamine** $(CH_3)_2HN + NO.OH =$ **Water + nitroso-dimethylamin** $(CH)_2NO.N$. TERTIARY AMINES are scarcely touched by nitrous acid. **Pyridine bases,** $\mathbf{C_nH_{2n-5}N}$, are metameric with **phenylamin** $C_6H_5.H_2N$, and its homologues, p. 112. They are contained in coal-tar, naphtha, and in Dippel's oil, which is obtained by the destructive distillation of bones. All liquid, and react as tertiary monamines. **Pyridin** C_5H_5N. **Picolin** C_6H_7N; boils at 133° C. Strongly alkaline, and forms crystalline salts. **Lutidin** C_7H_9N. **Collidin** $C_8H_{11}N$. **Parvolin** $C_9H_{13}N$. **Coridin** $C_{10}H_{15}N$. **Rubidin** $C_{11}H_{17}N$. **Viridin** $C_{12}H_{19}N$. CHINOLIN BASES $\mathbf{C_nH_{2n-11}N}$. By distillation of quinin, cinchonin, with KOH. **Chinolin** C_9H_7N. **Lepidin** $C_{10}H_9N$. **Cryptidin** $C_{11}H_{11}N$. LEUCOLIN, contained in coal-tar-oil, is isomeric

with chinolin. Heated with AMYL IODIDE $C_5H_{11}I$, chinolin forms $C_9H_7.C_5H_{11}NI$, which is changed by heating with KOH into **cyanin** $C_{28}H_{25}NI$, a dye of blue color. **Conin** $C_8H_{15}N$ $= (C_8H_{14})''HN$, in the seeds, &c., of *Conium maculatum*. By distillation with KOH. Colorless, oily liquid, of stupefying odor, browning on exposure. Sp. gr. 0.89. Boils at 168° C. Very poisonous. Temporary stain upon paper. Slightly soluble in water; freely in alcohol and ether. Vapor inflammable. A secondary monamine. METHYL CONIN $CH_3.C_8H_{14}.N$, also accompanies conin. With ethyl iodide, conin forms $C_8H_{14}.C_2H_5.N.C_2H_5I$, and this, by AgOH into a soluble base. (CONHYDRIN $C_8H_{14}.H_2NO$, accompanies conin.) **Nicotin** $(C_5H_7)_2'''N_2$, $= C_{10}H_{14}N_2$. In the seeds and leaves of *Nicotiana tabacum*, united with malic and citric acids. Also in tobacco smoke. Maryland and Havannah tobacco contain about 2 per cent. Colorless, oily liquid, irritating, and odorous of tobacco. Sp. gr. 1.048. Boils at 249° C. Very soluble in water, alcohol and ether. A fearful poison. With Cl, a red color. With I a ruby-red. **Spartein** $C_{15}H_{26}N_2$. Colorless liquid, alkaline, sparingly soluble, bitter, narcotic. **Creatin** $C_4H_9N_3O_2,OH_2$, in lustrous prisms, neutral, bitter. In juice of flesh. Artificially by union of CYANAMIDE $C(HN)_2$ with METHYL-GLYCOCIN or SARCOSIN $CH_3.HN.CH_2.COOH$. By boiling with water, into UREA and SARCOSIN. By abstraction of water, as when heated with acids, into **creatinin** $C_4H_7N_3O$. Creatinin constitutes 0.25 per cent. of the urine. It crystallizes in rhombic prisms, expels H_3N from its salts, and forms salts with acids. **Guanin** $C_5H_5N_5O$, a white powder, soluble in ClH. By oxydation into GUANIDIN CH_5N_3 and PARABANIC ACID $C_3H_2N_2O_3$, p. 107. Is contained in the pancreatic juice of mammals and largely in guano. **Xanthin** $C_5H_4N_4O_2$, in certain calculi; in the blood and urine, and in the liver. Artificially by moist sodium amalgam upon URIC ACID $C_5H_4N_4O_3$, and by NO.OH upon guanin. White, amorphous, slightly soluble in boiling water. Easily soluble in solution of H_3N. **Hypoxanthin** $C_5H_4N_4O$, crystallizes in needles, slightly soluble. Its hydrochloride sparingly soluble. It accompanies xanthin. **Carnin** $C_7H_8N_4O_3$, in meat-extract. **Theobromin** $C_7H_8N_4O_2$, in the seeds of *Theobroma Cacao*. White, crystalline powder, of bitter taste, slightly soluble, neutral. Forms salts with acids. From its solution in H_3N, silver nitrate precipitates $C_7H_7AgN_4O_2$, which, by heating to 100° C. with CH_3I, is changed into: **thein** or **methyl-theobromin** $C_7H_7(CH_3)N_4O_2$. In tea and coffee; in the leaves of *Ilex paraguayensis*, and in Guarana, the dried pulp of the fruit of *Paullinia sorbilis*. In silken needles as $C_8H_{10}N_4O_2,OH_2$, soluble in water and alcohol. Melts at 225° C., and sublimes. Boiled with baryta-water $+ OH_2 =$ **theidin** $C_7H_{12}N_4O + CO_2$. By the

action of Cl or of nitric acid, methylamin and cyanogen chloride are evolved. and AMALIC ACID (TETRA-METHYL ALLOXANTIN) $C_8(CH_3)_4N_4O_7$ is obtained.

Alkaloids of opium. Opium, the inspissated juice of the half-ripe capsules of *Papaver somniferum*, contains various bases united with sulphuric and meconic acids. By digestion of the opium with warm water, and filtration, we remove narcotin principally, with some resinous matters, &c., and obtain morphin, codein, thebain, papaverin, narcotin and narcein in solution as meconates and sulphates, together with **meconin** $C_{10}H_{10}O_4$ and extractive matters. Opium acts as a sedative, and in larger doses as a narcotic poison. On addition of calcium chloride to the aqueous solution, calcium meconate is thrown down, and hydrochlorides of the alkaloids are found in solution.

N.B. MECONIC ACID $C_4HO(COOH)_3,3OH_2$ = $C_7H_4O_7,^3OH_2$ or OXYCHELIDONIC ACID (CHELIDONIC ACID $C_7H_4O_6$, in *Chelidonium majus*, together with ACONITIC ACID $C_6H_6O_6$ in *Chelidonium* as also in *Aconitum napellus*) in mica-like plates, easily soluble in boiling water, gives a deep-red color to ferric salts, not bleached by Cl_2Hg. Easily separated from calcium meconate by ClH. Triatomic, tribasic. Soluble meconates are precipitated by lead acetate.

Morphin $C_{17}H_{19}NO_3,OH_2$, in small, brilliant prisms, soluble in 1000 parts of cold water; alkaline to test-paper and of bitter taste. Soluble in 30 parts of boiling alcohol, and easily in dilute acids: insoluble in chloroform and in ether. Soluble in excess of KOH. Precipitated from solutions of its salts by KOH, by H_3N and by $CO(ONa)_2$. Melts to dark-red fluid, and burns with sooty flame, leaving a little charcoal which easily burns away. Neutral ferric chloride strikes a blue color. With nitric acid, an orange color, very characteristic. Liberates I from IO_3H, which is dissolved with amethystine color by chloroform or carbonic sulphide, and colors starch blue. From MORPHIN HYDROCHLORIDE $C_{17}H_{19}NO_3,ClH,3OH_2$, morphin may be precipitated by H_3N. Solution of iodine precipitates $C_{17}H_{19}NO_3I_4$. [**Apomorphin** $C_{17}H_{17}NO_2$, by heating morphin in an hermetically-sealed tube with 2ClH. Is an emetic. Is soluble in ether and in chloroform.] **Codein** or **methyl-morphin** $C_{17}H_{18}(CH_3)NO_3,OH_2 = C_{18}H_{21}NO_3,OH_2$. Large rhombic prisms, which melt at 120° C. With soda-lime yields methyl-amin, and trimethylamin. Heated with strong ClH at 145° C., into methyl chloride and apomorphin. Tertiary monamine. From its greater solubility, codein hydrochloride remains in solution after morphin hydrochloride has crystallized out. **Thebain** $C_{19}H_{21}NO_3$ in silvery scales, insoluble in water, KOH and in H_3N. Present in very small quantity. Produces tetanus. **Papaverin** $C_{20}H_{21}NO_4$, in minute crystals. Like

Cryptopin, gives with SO_4H_2 a deep-blue color. **Narcotin** $C_{22}H_{23}NO_7 = C_{19}H_{14}(CH_3)_3NO_7$, in small, colorless prisms, is obtained from the *marc* or insoluble portion by boiling with dilute acetic acid, and precipitation by NH_3. Soluble in 128 parts of boiling alcohol and 19 of boiling ether. Heated with KOH, yields H_3N and CH_3H_2N, as well as $(CH_3)_2HN$ and $(CH_3)_3N$. Treated with $3HI = 3CH_3I$ + **nornarcotin** $C_{19}H_{17}NO_7$, or three molecules of methyl iodide for one of the new base.

Alkaloids of cinchona. **Cinchonin** $C_{20}H_{24}N_2O$, in transparent, four-sided prisms, very little soluble in water, yet alkaline to test-paper. Soluble in 30 parts of boiling alcohol; nearly insoluble in ether. A powerful base; produces powerful right-handed rotation. In pale bark, or *Cinchona Condaminea*. $(C_{20}H_{24}N_2O)_2SO_4H_2,2OH_2$, in lustrous crystals, fairly soluble. **Cinchonicin** and **Cinchonidin** are isomeric; the first is feebly right-handed, the latter strongly left-handed as to polarized rays.

Quinin $C_{20}H_{24}N_2O_2,3OH_2$ in minute silken needles, more soluble in water, intensely bitter and alkaline; deviates the plane of polarization to the left. A valuable febrifuge. Very soluble in ether, and gives a green color with Chlorine-water and Ammonia. Abundant in yellow Cinchona bark, *Cinchona calisaya*. $(C_{20}H_{24}N_2O_2)_2,SO_4H_2,7aq.$, requires 800 parts of cold water for solution. Solution has a blue fluorescence. **Quinidin** is isomeric, but produces powerful right-handed rotation. **Quinicin** $C_{20}H_{24}N_2O_2$, is also isomeric, and like cinchonicin is produced by heat respectively from quinidin and cinchonidin. **N.B.** These alkaloids are contained as **Kinates** chiefly. The so-called KINIC ACID $C_6H_7(OH)_4COOH$, in colorless prisms. Easily obtained from CALCIUM KINATE $(C_7H_{11}O_6)_2Ca,10aq.$, by means of oxalic acid. By digesting the ground bark in dilute sulphuric acid, and precipitation of the bases by lime or magnesia.

Alkaloids of strychnos. In the seeds of *Strychnos nux-vomica*, and in *Strychnos Ignatius*, STRYCHNIN and BRUCIN are found. The expressed seeds are exhausted by dilute sulphuric acid, and the bases precipitated by calcium hydroxide: brucin is removed by washing with cold alcohol. **Strychnin** $C_{21}H_{22}N_2O_2$, in colorless rhombic prisms, almost insoluble in water, and yet intensely bitter, and alkaline. Almost insoluble in ether and absolute alcohol, but very soluble in ordinary spirit of wine and in chloroform. A fearful poison. With PbO_2 and also with MnO_2 and SO_4H_2, gives beautiful purple reaction, turning to brown. Also with $K_2Cr_2O_7$ and SO_4H_2. Potassium sulphocyanide precipitates sulphocyanide of strychnin. **Brucin** $C_{22}H_{26}N_2O_4$, in efflorescent prisms, or in tables with 4 aq. Easily soluble in alcohol, but not in ether. Red with SO_4H_2, and gives a violet precipitate when $SnCl_2$ is added to the red solution. Orange

color with $NO_2.OH$, for which it is also a test. *Brucea antidysenterica* only contains brucin. Less poisonous than strychnin.

Other alkaloids. Atropin $C_{17}H_{23}NO_3$, in *Atropa Belladonna*, and in *Datura Stramonium*. Thin needles, of bitter taste, very poisonous. Unchanged in the urine. Easily soluble in alcohol, but little in water and ether. Produces dilatation of the pupil of the eye. By heating with $(OH)_2Ba$ or with ClH, by assimilation of OH_2 into TROPIC ACID $C_9H_{10}O_3$ and **tropin** $C_8H_{15}NO$. **Veratrin** $C_{32}H_{52}N_2O_8$, in seeds of *Veratrium Sabadilla*. White powder, of sharp burning taste, occasioning sneezing. Very poisonous. Nearly insoluble, and yet alkaline. **Jervin** $C_{30}H_{46}N_2O_3$, in the root of *Veratrum album*. [**Piperin** $C_{17}H_{19}NO_3$, in four-sided prisms, insoluble in water; easily soluble in alcohol and ether. From seeds of *Piper niger*. Heated with soda-lime it yields PIPERIDIN $C_5H_{10}HN$, a secondary amine. **Sinapin** $C_{16}H_{23}NO_5$, in seed of *Sinapis alba*, as thiocyanide, soluble in alcohol. By boiling with alkalies ($+2OH_2$) = **cholin** $C_5H_{15}NO_2$, and SINAPIC ACID $C_{11}H_{12}O_2$. **Hyoscyamin** $C_{15}H_{23}NO_3$, in *Hyoscyamus niger*. **Berberin** $C_{20}H_{17}NO_4$, in the root of *Berberis vulgaris*. With $5OH_2$ in yellow needles. **Physostigmin** $C_{15}H_{21}N_3O_2$, in the Calabar bean. In laminæ soluble in alcohol and ether. A fearful poison. Occasions contraction of the pupil. **Curarin** $C_{10}H_{15}N$. **Lycin** $C_5H_{11}NO_3$, in the leaves of *Lycium barbarum*. **Harmalin** $C_{13}H_{14}N_2O$ and **Harmin** $C_{13}H_{12}N_2O$ are in the seeds of *Peganum harmala*. **Colchicin** $C_{17}H_{19}NO_3$, in the seeds of *Colchicum autumnale*. **Cocain** $C_{17}H_{21}NO_4$, in coca-leaves. **Corydalin** $C_{18}H_{19}NO_4$. **Chelidonin** $C_{19}H_{17}NO_4$, in the roots of *Chelidonium majus*. **Emetin** $C_{30}H_{44}N_2O_8$, in *Radix Ipecacuanhæ*. **Solanin** $C_{43}H_{69}NO_{16}$ in the sprouts of *Solanum tuberosum*.]

Gelatiginous principles including bone, teeth, hair, nails, &c.

Gelatin and **Chondrin** are not ready-formed, but result from the action of boiling water upon the gelatigenous or chondrin-producing tissues.

	Gelatin.	Chondrin.
Carbon	50.0	49.1
Hydrogen	6.6	7.1
Nitrogen	18.3	14.4
Oxygen	25.1	29.4
	100.0	100.0

Gelatin swells up in cold water, and dissolves on boiling to a viscid liquid, which solidifies to a jelly on cooling. "Size" from parchment, "glue" from bones, and "isinglass" from the floating bladder of sturgeons, are more or less pure gelatin. Insoluble in alcohol and ether, and is precipitated also by Cl_2Hg, $(NO_2)_2O_2Hg$, and $(NO_2)_2O_2Hg_2$. TANNIN $C_{14}H_{10}O_9$ (p. 115),

precipitates it as TANNO-GELATIN, and the tissues which yield gelatin, unite directly with tannin to "leather." Boiled with sulphuric acid or with alkalies, gelatin yields both LEUCIN $C_6H_{13}NO_2$, or AMIDO-CAPROIC ACID $\mathbf{C_5H_{10}(H_2N)(COOH)}$ and GLYCOCIN $C_2H_5NO_2$ (or AMIDO-ACETIC ACID $\mathbf{CH_2(H_2N)(COOH)}$. **Leucin** crystallizes in lustrous scales, but little soluble in water. It unites with acids and bases. Heated with $(OH)_2Ba = \mathbf{C_5H_{11}.H_2N} + CO.O_2Ba$. **Chondrin,** from the ribs and joints, is precipitated from its solutions by acetic acid, alum, lead acetate and other metallic salts, and not by mercuric chloride. With sulphuric acid, **only** LEUCIN. Boiled with ClH, gives GLUCOSE.—**Sericin** $C_{15}H_{25}N_5O_8$. Soluble in boiling water, and solidifies on cooling to a jelly. Is precipitated by Cy_6FeK_4, and by various metallic salts. Boiling with sulphuric acid, sericin affords besides LEUCIN $C_6H_{13}NO_2$. and TYROSIN $C_9H_{11}NO_3$, **serin or amido-glyceric acid** $CH_2.H_2N.CHOH.COOH$ (hard crystals changed by NO.OH into GLYCERIC ACID $C_3H_6O_4$ or DIOXY-PROPIONIC acid.)—**Fibroin** $C_{15}H_{23}N_3O_6$, constitutes 66 per cent. of silk. Insoluble in hot water, in alcohol and ether. Boiled with sulphuric acid, gives leucin, tyrosin and glycocin.

Albuminoids or proteids. Approximate formula $C_{72}H_{112}N_{18}O_{22}S$. They also contain phosphates. Boiled with ClH. and Cl_2Sn, they are resolved into H_3N, $C_6H_{13}NO_2$. $C_9H_{11}NO_3$, ASPARTIC ACID and GLUTAMIC ACID $C_3H_5.H_2N(COOH)_2$. They are precipitated by mineral acids; by Cy_6FeK_4 with a little acetic acid; by acetic acid; by Millon's reagent (mercuric nitrate), a deposit, and a solution which turns red. They also rotate the plane of polarization to the right. **Class I.** ALBUMINS: **soluble in water.** *a.* SER-ALBUMIN, yellow, elastic, transparent, soluble, and precipitated by alcohol, which slowly changes it into coagulated albumin. Not precipitated by very dilute acids in small quantities. Immediately by strong acids, especially nitric acid, in which it is easily soluble. Concentrated NO_2OH produces a bright orange color. **Aqueous solution coagulated by boiling; albumins.** NOT COAGULATED: **Peptones.** All albuminoids changed into **Peptones** by gastric juice. *b.* OVALBUMIN, gradually gives a precipitate when shaken with ether, and is nearly insoluble in nitric acid. (The yolk of an egg contains albumin and casein.) *c.* VEGETALBUMIN resembles ovalbumin. **Class II.** GLOBULINS: **insoluble in water.** Insoluble in water, **but soluble in 1 per cent. solution of ClNa** or other neutral salts. *α.* **Myosin,** insoluble in water, but soluble in very dilute ClH, rapidly passing into acid-albumin. It is also coagulated by alcohol. Occurs in the protoplasma, or contractile muscular substance causing *rigor mortis*. *β.* **Globulin.** Suspended in water, and heated to 70° C., it becomes coagulate and insoluble. By dilute acids into acid-albumin. In dilute alkalies, soluble as

albuminate. Is precipitated from its saline solution by CO_2, and is prepared from diluted blood-serum by a stream of CO_2. Globulin also in aqueous humour, in the juice of the cornea, &c. Globulin from blood-serum is FIBRINO-PLASTIC. γ. **Fibrinogen** is more difficult to precipitate by CO_2 than globulin, more flaky, and more easily precipitated by alcohol-ether. It is moreover FIBRINOGENOUS, producing fibrin when mixed with fibrino-plastic globulin. Prepared from pericardial fluid, or hydrocele fluid, or any other, capable of producing a clot with blood-serum. **Class III.** DERIVED ALBUMINS. **Insoluble in water and in dilute solutions** (1 per cent.) **of sodium chloride: soluble in dilute acids and alkalies.** A. ACID ALBUMIN. All the globulins of Class II. are soluble in dilute acids, and thus converted into acid albumin, and the precipitate on neutralization is no more soluble in neutral salines. And so, if dilute **ClH** or **CH_3COOH**, be added to ser- or ov-albumin, no coagulation takes place on heating to 70° C. or above, but rotation to the left is increased: on neutralization, a white, gelatinous precipitate is occasioned, and soluble albumin becomes **insoluble** in **water,** as in hot **alcohol.** Suspended in water and heated to 70° C., it enters into the coagulated state. B. **Alkali-albumin** or **albuminate. Casein.** Alkalies similarly prevent coagulation; on neutralization the albumin is similarly precipitated. Hot alcohol re-dissolves alkali-albumin. Casein, from milk, has similar properties: it is coagulated by infusion of rennet. **Class IV.** FIBRIN. **Insoluble in water and in dilute (1 per cent.) hydrogen chloride, except when heated to** 60° C. **Fibrin** is filamentaceous, and elastic, insoluble in water, but soluble in solution of saltpetre at 40° C. The formation of fibrin due to contact of fibrinoplastic with fibrinogenous substances, which combine. GLUTIN consists mainly of vegetable fibrin and glutin. **Class V. Coagulated proteid. Insoluble in dilute, as well as in strong acids: soluble in gastric juice.** Produced when neutral solutions of albumin, syntonin, fibrin, myosin, &c., are boiled or precipitated by alcohol. Ovalbumin is also coagulated by ether, and by strong ClH. Casein and albuminates, when precipitated from neutral solutions, pass into coagulated albumin by heat: and they are changed back by caustic potash into albuminates. **Class VI. Peptones.** All albuminoids changed into peptones by the gastric juice: they are found in the stomach and small intestines. Easily soluble in water, and insoluble in alcohol and ether. Not precipitated by acids nor by potassium ferrocyanide, but by Cl_2Hg and lead acetate with ammonia.

Bones when dried at 100° C. consist of about one-third of organic matter; the remaining two-thirds being composed chiefly of **calcium ortho-phosphate,** with **calcium carbonate** and **magnesium phosphate.** By boiling in a Papin's digester at 150° C.,

the gelatin is dissolved, and the earthy matters are left. The **teeth** are similar, but the portion which projects over the gums is encased with a compact hard crust, known as the **enamel**, and which contains but a very small proportion of animal matter.

Blood is the source of all nutriment and all secretions. Average sp gr. of human blood is from 1.052 to 1.057, varying in the proportion of the red corpuscles. The SERUM is more uniform, between 1.027 and 1.029; alkaline, straw-colored, highly albuminous. Heated to 76°.7 C., it coagulates to a semi-transparent jelly owing to the presence of 7.78 per cent. of albumin. The solid CRUOR or CRASSAMENTUM begins to separate from three to five minutes after the blood has been drawn, and is traced to the action of fibrino-plastic and fibrinogenous bodies; by strong agitation no coagulation, as the fibrin separates in coherent filaments. The blood-discs or red blood-corpuscles consist in chief part of **hæmoglobin**, or **hæmatocrystallin.** Usually amorphous, but crystalline from cats, dogs, rats, mice, and many fish. A brick-red powder, soluble in water, and precipitated by alcohol: its aqueous solution exhibits in its spectrum two absorption-bands situated between the Fraunhofer lines D and E. The solution containing **O** has a deep-red color and exhibits the absorption-bands; free from **O** is dark-purple. Oxygenated hæmoglobulin is resolved by dilute acids or alkalies into two proteids, fatty acids, and **hæmatin** $C_{34}H_{34}FeN_4O_5$, a dark-blue powder when dry, containing 9 per cent. of iron. When blood is warmed with strong acetic acid, and solution of ClNa, a substance called **hæmin**, separates in yellowish-red, microscopic, rhomboids: *a test* for blood.

Brains. Besides 80 per cent. of water. and 7 per cent. of albumin, the brain contains (in addition to small quantities of kreatin, lactic acid, uric acid, inosite, &c.) fats, cholesterin, cerebrin and lecithin. **Cerebrin** $C_{17}H_{33}NO_3$ is a tasteless substance, insoluble in cold ether. It swells up when boiled with water. **Lecithin** $C_{42}H_{84}NPO_9$, occurs also in yolk of eggs, blood-corpuscles, &c. It is a waxy substance, soluble in alcohol and ether; swells up with water, forming an opalescent solution. It unites with basyls and radicles. Forms $(C_{42}H_{83}NPO_8Cl)_2.Cl_4Pt$ By boiling with acids, lecithin into: CHOLIN $C_5H_{15}NO_2$, and GLYCERO-PHOSPHORIC, PALMITIC and OLEIC ACIDS.

Bile. A greenish viscid liquid, which darkens on exposure to air. Alkaline, of disagreeable odor, freely miscible with water, and of bitter taste. Evaporated at 100° C., and treated with alcohol, a thick jelly of MUCUS is left. The alcoholic solution contains COLORING MATTER and CHOLESTERIN $C_{26}H_{43}OH$ (p. 131). The BILE-PIGMENTS are: *a.* **bilirubin** $C_{16}H_{18}N_2O_3$, the chief coloring matter, forming dark-red prisms, insoluble in

water, and sparingly soluble in alcohol and ether. Easily soluble in $CHCl_3$ and in S_2C. Soluble in hydroxides, with yellowish-red color; when shaken with air, **biliverdin** $C_{16}H_{20}N_2O_5$, of green color, precipitates. *b.* **Bilifuscin** $C_{16}H_{20}N_2O_4$ is dark-green, soluble in alcohol, but insoluble in chloroform and in water. With nitric acid, all the pigments give a green color, changing to blue, violet, red and yellow. A test. Besides **cholin** $C_5H_{15}NO_2$ (which has the composition of tri-methyl ethene hydrinammonium hydroxide $C_2H_4.OH.(CH_3)_3N.OH$), the bile contains two peculiar acids. 1. **Glycocholic acid** $C_{26}H_{43}NO_6$, slender needles, sparingly soluble in water, easily in alcohol. In the bile, as GLYCOCHOLATE OF SODIUM $C_{26}H_{42}NO_5ONa$. On addition of sugar and $SO_2(OH)_2$, a purple-red color (Pettenkofer's test). By boiling with alkalies ($+ OH_2$) into GLYCOCIN $CH_2(H_2N)COOH$, and **cholic acid** $C_{24}H_{40}O_5$: boiled with acids, first into glycocin and cholic acid, and the latter then into **dyslysin** $C_{24}H_{36}O_3$. 2. **Taurocholic acid** $C_{26}H_{45}NSO_7$, also in slender needles, easily soluble in water and alcohol. By boiling with water ($+ OH_2$), into CHOLIC ACID $C_{24}H_{40}O_5$, and **Taurin** $C_2H_4(H_2N)SO_3H$, p. 97. In the bile as TAUROCHOLATE OF SODIUM. The bile of pigs contains sodium salts of **hyoglycocholic acid** $C_{27}H_{43}NO_5$ and **hyotaurocholic acid** $C_{27}H_{45}NSO_6$. (HYOCHOLIC ACID $C_{25}H_{40}O_4$.) Goose-bile contains **chenotaurocholic acid** $C_{29}H_{49}NSO_6$. (CHENOCHOLIC ACID $C_{27}H_{44}O_4$.) *Oriental bezoarstones* contain ELLAGIC ACID $C_{14}H_8O_9$ and **lithofellic acid** $C_{20}H_{36}O_4$: the latter gives with sucrose and $SO_2(OH)_2$ a purple color.

Chyle is an opalescent fluid of a yellowish-white, or pale reddish color. Feebly alkaline, more or less milky from suspended fat globules, and deposits, when boiled, a few albuminous flocculi. Resembles blood, but is far more dilute. Fibrin is greatest when the chyle taken from fasting animals. **Lymph** is a yellowish or colorless fluid, also of faint alkaline reaction. Like blood and chyle it contains fibrin. The albumin in it varies from 0.4 to 6.0 per cent., and of fibrin from 0.3 to 0.5 per cent. in human beings. **Milk**, as seen under the microscope, forms a transparent fluid, containing innumerable transparent oily globules; these globules are contained in a thin membrane which is not visible until the milk is treated with dilute acetic acid. Albumin is only present in *colostrum*, or the milk produced after birth. The quantity of **salts** in cow's milk amounts to about 0.73 per cent.; the phosphates are the most important. Cow's milk varies in sp. gr. from 1030 to 1040. It contains about 12.5 per cent. of total solids: FAT 3.25; LACTOSE and soluble salts 5.20; CASEIN and insoluble salts 4.05.

Among the liquids concerned in digestion (besides bile) we

notice: **Saliva.** An opalescent, viscid liquid, which froths on agitation. The solids vary from 0.4 to 0.84. In addition to epithelial particles, and to the mucus derived from the mouth, the saliva contains **ptyalin** which resembles sodium albuminate. It constitutes one-third of the soluble solids of the saliva, and converts starch into dextrin and dextrose. Further, the saliva is faintly alkaline. Besides carbonates and lactates of potassium and sodium, it contains sulphocyanide of potassium, carbonate and phosphate of calcium, the two last, together with salivary mucus, constituting the *tartar* of teeth. **The gastric juice** effects the digestion of the albuminoid constituents of food. It is a clear colorless liquid, of peculiar odor; very acid after ingestion of food. Very powerful antiseptic. Does not become turbid when boiled. The acid consists of lactic and hydrochloric acids, with traces of butyric and propionic. Besides certain salts, it contains **Pepsin**, an albuminoid body, soluble in water, but insoluble in alcohol or in ether. When boiled, pepsin loses its power of effecting digestion: its aqueous solution is precipitated by Cl_2Hg, but not by Cy_6FeK_4, in acetic acid solutions. Dried pepsin with 20 to 50 per cent. of starch, is an article of commerce. The **Pancreatic fluid,** somewhat resembles saliva. It aids in the assimilation of fats. Sp. gr. 1.008. Contains about 10 per cent. of solids, among which LEUCIN $C_5H_{10}.H_2N.COOH$, XANTHIN $C_5H_4N_4O_2$, GUANIN $C_5H_5N_5O$ and INOSITE $C_6H_{12}O_6$. Further it contains albumin, and becomes coagulated when heated. **Mucus.** A tough, viscid secretion, in which epithelial particles can be traced in different stages of disintegration. It swells up in, but is not dissolved by, water: MUCIN gives the glairy consistence to the mass, and is turned yellow by nitric acid, *not* precipitated by Cl_2Hg, but coagulated by alcohol.

The Urine. From arterial blood by the kidneys. Average sp. gr. 1.02. The quantity passed by an adult varies from 40 to 50 oz. per day. Amber-colored, of slight acid reaction, and peculiar odor. It soon begins to putrefy, and becomes alkaline from the conversion of UREA $\mathbf{CON_2H_4}$ + $2OH_2$ into AMMONIUM CARBONATE: the mucus of the bladder acting as a ferment. Besides WATER 95.680 per cent., and UREA CON_2H_4, 1.420 per cent., the urine contains MUCUS 0.016, URIC ACID $C_5H_4N_4O_3$, 0.037 per cent., ALCOHOLIC EXTRACT 1.253, AQUEOUS EXTRACT 0.250, SODIUM CHLORIDE 0.722, PHOSPHATES, SULPHATES, &c., 0.613 per cent. The urine of herbivora is rich in HIPPURIC ACID $CH_2.NH.C_7H_5O.COOH$. The coloring matters of the urine. UROCHROME and UROMELANIN $C_{36}H_{43}N_7O_{10}$. The urine is the chief outlet of the effete nitrogenized tissues. Lehmann secreted 821 grains of urea, and 21.6 grains of uric acid, per 24 hours, on an animal diet; on a vegetable diet 348 grains of

urea, and 15.4 grains of uric acid. Sulphates increase greatly in the urine with animal food. All salts of potassium, sodium and ammonium with vegetable acids, taken as such, are voided as carbonates. In certain diseases, ALBUMIN is found in the urine. In diabetes, the urine contains much DEXTROSE. **Chief calculi** are: 1. URIC ACID. 2. AMMONIUM URATE. The deposit so common in urine, of a pink color, is urate of ammonium. 3. CALCIUM OXALATE. "Mulberry calculus." 4. CALCIUM ORTHO-PHOSPHATE: infusible. 5. AMMONIUM MAGNESIUM PHOSPHATE. "Triple phosphate." "FUSIBLE CALCULUS" is a mixture of 4 and 5. 6. XANTHIN $C_5H_4N_4O_2$; very rare. 7. CYSTIN $C_3H_6NSO_2$.—An important biliary calculus consists mainly of CHOLESTERIN $C_{26}H_{43}OH$.

The solid excrements or **fæces** consist of about 75 per cent. of water; the rest, of biliary matters and alimentary débris According to LIEBIG, about $5\frac{1}{2}$ ounces are excreted in 24 hours by a healthy adult. The odor is the more offensive as the quantity of bile diminishes. Marcet has discovered EXCRETIN $C_{78}H_{156}SO_2$.

Pus is a thick, opake, yellowish fluid, which, under the microscope is seen to consist of a transparent liquid, in which a large number of corpuscles float. It is feebly alkaline, and holds a considerable quantity of albumin in solution; LEUCIN $C_5H_{10}(H_2N)COOH$, is also often present, and has been already mentioned at pp. 126 and 130. [Leucin is further formed by the decomposition of gelatin, wool and horn, &c., during putrefaction. Indeed, it was first discovered in putrid cheese. The crystals melt at 100° C., and sublime. Nitrous acid changes leucin into LEUCIC ACID $C_6H_{12}O_3$. It is produced artificially from BROMO-CAPROIC ACID by ammonia, and by digesting VALERAL-AMMONIA with cyanide of hydrogen and chloride of hydrogen. Thus: $C_5H_{10}O.H_3N + CNH + OH_2 + ClH = H_4NCl + \mathbf{C_5H_{10}.H_2N.COOH}$.] The pus-globules contain both fat and CHOLESTERIN $C_{26}H_{43}OH$, the latter having the composition of a monatomic alcohol. It is a lustrous, fat-like substance, soluble in boiling alcohol, in ether and in chloroform. It melts at 137° C., and sublimes at 200° C. It is the chief constituent of biliary calculi (p. 128). PYIN is the name of the albuminoid substance found in pus; it is soluble in water, but precipitated by acetic acid as well as by alum. The saline constituents exceed 12 per cent. of the total dry matter.

THE END.

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